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BRITISH FOUNDRYMEN'S ASSOCIATION.

NOTICE TO MEMBERS.

The annual Convention for 1906 will be held at Middlesbrough on August 7th, 8th, and 9th. The voting to decide which city should be selected was Middlesbrough 64, Sheffield 13, and Birmingham 16. A detailed programme will be sent to each member as soon as ready. It is hoped that a good number of members will attend.

F. W. FINCH,
Hon. Sec.

BRITISH FOUNDRYMEN'S ASSOCIATION.

THE second meeting of the Birmingham Branch of the above Association was held in the large theatre of the Birmingham Technical School, before a good audience, on May 10, 1906, when the appended paper on the "Influence of Certain Chemical Elements on Cast Iron" was read by Mr. A. H. Hiorns, head of the Metallurgical Department of the Birmingham Technical School.

After the reading of the paper, discussion was entered into by Messrs. Buchanan, Mason, Cook, and Hailstone.

Influence of Certain Elements on Cast Iron.

BY ARTHUR H. HIORNS.

Cast iron is the most complex of the three chief classes of iron, in virtue of the greater number of constituents which enter into its composition, and the combinations which these constituents form among themselves. Of the essential constituents, carbon is by far the most important, as upon the amount and mode of existence of this element depend the distinctive properties of the several classes of pig-iron. The other elements present are of importance in proportion to their effect on the relation of carbon to iron. Pig-iron generally consists of iron with upwards of 2 per cent. of carbon, and varying proportions of silicon, manganese, phosphorus, and sulphur. Constituents other than these may be considered as impurities, such as nickel, copper, tungsten, titanium, chromium, arsenic, etc., unless they are purposely introduced so as to produce brands of iron for specific purposes.

Carbon exists in pig-iron in two chief forms, as graphite or free carbon, and in what is generally termed the combined form. Manganese and silicon can exist as isomorphous mixtures with iron. Manganese can also, like iron, unite with carbon to form a carbide, or with iron and carbon to form a double carbide; with silicon to form a silicide, and with

sulphur to form a sulphide, and also with oxygen to form an oxide. Manganese, therefore, influences the properties of pig-iron in virtue of its combination with carbon, silicon, sulphur, and oxygen. Sulphur may exist as a sulphide of iron and a sulphide of manganese. Phosphorus exists in cast iron as a phosphide, and thus is capable of forming with iron and carbon a complex eutectic mixture, having a melting point of 980 degrees C. Phosphide of iron may exist in solution, but the presence of carbon tends to throw this phosphide out of solution. Phosphide eutectic may contain phosphide and carbide of iron in the form of plates, silicide of iron and pearlite.

Having now briefly enumerated the effects of the elements usually present in cast iron, it will be advisable to study them in detail.

Carbon.—Cast iron when in the liquid state may be considered to be a saturated solution of carbon and other elements in iron, the carbon generally being about 3 per cent. The amount of carbon varies with the nature and amount of other elements present, some of which increase and others diminish the total quantity. Chromium and manganese increase the solvent power for carbon, while silicon and aluminium act in the opposite direction. Iron with 20 per cent. of silicon only dissolves about 1 per cent. of carbon. It is, however, unusual to meet with less than 2 per cent. or more than 4 per cent. of carbon in cast iron. Formerly the condition of carbon in cast iron was considered in only two forms: graphite in grey iron and combined carbon in white iron.

One thing is beyond question, that carbon does exist in grey iron as graphite, but whether the carbon does unite chemically with iron in white iron, or exists simply in solution in the iron, has not been satisfactorily determined. It is probable, however, that a definite compound does exist similar to, if not identical with, the free carbide, Fe_3C, in steel. Possibly there may be more than one compound, or more than one alloy, dissolved in the main mass of iron.

With respect to steel which practically consists of only carbon and iron, two constituents are present, namely crystals of pure iron, termed "ferrite," and the carbide, Fe_3C, termed "cementite." These two constituents arrange themselves in certain proportions to form a eutectic mixture termed "pearlite." When steel is rapidly quenched from a red heat the carbon remains in solution, and this solid solution has been termed "martensite." When steel contains 0.9 per cent. of carbon it is said to be saturated and consists entirely of the eutectic mixture pearlite. The condition of carbon in steel and cast iron at the different temperatures has been indicated by the following scheme by Roberts-Austen and others, in which is shown the nature of the metal in the different zones.

Above 1,130 degrees C. in the zone marked 1 we have the molten metal with carbon in solution. In the zone II. we have still the carbon in the liquid solution, but some martensite containing 2 per cent. carbon has crystallised out as a solid solution. In zone III. we have the iron with some of the carbon in solution, but the rest has separated as graphite. In zone IV. the whole solidified mass is martensite, but this is with less than 2 per cent. carbon, and, therefore, is not cast iron. In zone VII. we have martensite and graphite. Now if the iron is kept for a long time at the temperature of this region the martensite will be decomposed into ferrite and graphite, but if sufficient time is not allowed the carbon will remain in solution as martensite. In zone VIII. we have martensite and cementite, with some graphite, if such graphite has once been formed in the previous zone; and iron and graphite if the carbon has been previously completely separated as graphite. In zone IX. another change has occurred, and pearlite is present, if sufficient time has been allowed for its formation at about 700 degrees C., that is, at the line H.I. The martensite is decomposed into cementite and ferrite.

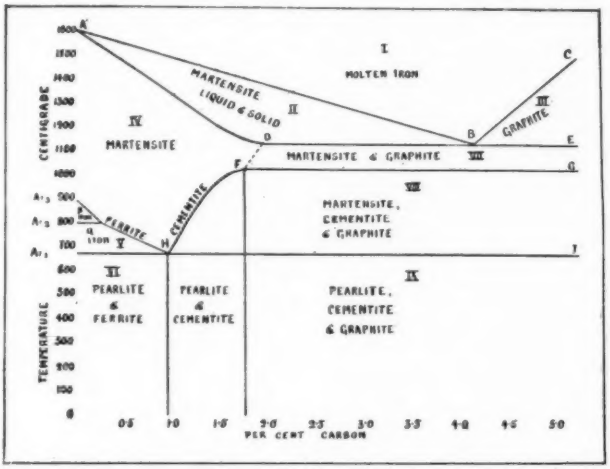
But the phenomena of superfusion plays a part in the above-mentioned changes, and we may get grey, ultra grey and white or mottled cast iron from the same solution according to the foreign elements present. Thus, sulphur and manganese retard the separation, and silicon stimulates the separation of graphite. The effects of temperature on different grades of cast iron may be stated thus.

Ordinary Grey Cast Iron.—Owing to the slow cooling and the presence of silicon in the zone VII. the change from graphite to cementite in the zone VIII. is largely prevented and the graphite remains in the iron when cold. It is possible that silicon has the power of decomposing martensite in the zone VII., and this produces the stable condition of ferrite *plus* graphite. It has been suggested that silicon prevents supercooling, and therefore assists in the separation of graphite.

Extra Grey Cast Iron.—Here the re-

actions referred to in the last section are complete. The martensite is completely decomposed, silicon is generally largely present, and the counteracting elements, manganese and sulphur, practically absent. The conditions of slow cooling in zone VII. has been extended and the conversion of martensite and graphite to cementite prevented. The stable condition has been perfectly attained.

White Cast Iron.—This may be readily produced from iron and carbon alone without the intervention of other elements, provided the metal is cooled quickly from the freezing point. We may assume the liquid solution in the rapid freezing has not had sufficient time to



separate into martensite and graphite, and therefore the iron largely contains the carbon in solid solution, or supersaturated martensite. With less rapid cooling, some martensite and graphite will separate out, forming a eutectic mixture. The presence of silicon would assist in this change, while manganese and sulphur would prevent it. White iron is in a position of unstable equilibrium, and therefore very easily fractured. All stages between entirely grey and entirely white may be obtained by suitable composition and heat treatment. In chilling of cast iron the same result occurs, and in a large casting we may get all grades in passing from the outside to the inside. In white iron we never exceed the limit of 4.3 of carbon, unless the manganese is very high, and therefore the conditions in zone III. do not come into account.

Malleable Cast Iron.—In malleable castings a white iron is used, and therefore one with very little graphite. The annealing which requires several days at a temperature of 1,000 degrees C. raises the iron to the margin of the temperature of zone VII. in which martensite or cementite may decompose into a state containing graphite. Now at this temperature the action is exceedingly slow and the graphite only separates in a finely divided state termed "temper graphite." The carbon on the surface is removed by the oxide of iron in which the iron is embedded, and the remaining iron is decarburised by the diffusion of graphite from the interior. The graphite has no opportunity of coalescing into flakes, as it does when slowly cooled from the freezing point, and it therefore remains as an impalpable powder, which is much less weakening than when graphite is in large flakes, as in ordinary grey iron and very much less brittle than white iron. Malleable cast iron and grey cast iron differ essentially in their structure and in the mode of their formation.

Howe has elaborated the view that cast iron may be considered as steel, with more or less graphite disseminated through the mass. Very mild steel consists almost wholly of ferrite. As the carbon increases the crystals of ferrite decrease in size and the space between them is filled up with pearlite, until 0.9 per cent. of the

whole mass consists of pearlite. When the carbon exceeds 0.9 per cent. free cementite appears as a network surrounding grains of pearlite. The amount of cementite increases with the increase of carbon, and the pearlite correspondingly decreases, until at about 2 per cent. the metal is termed white cast iron. Steels and white cast iron thus form a continuous series, and microscopically there appears no difference, except one of degree, between high carbon steels and white cast irons. In a similar way the various grades of grey iron and mottled iron may be considered as members of the steel-white iron series containing more or less free graphite. Thus, very grey iron may be considered as mild steel *plus* graphite, and its structure consists almost entirely of ferrite *plus* graphite. As the amount of combined carbon increases, the matrix of the iron may be considered as steel, made weak and brittle by the interposing plates of graphite, and as mild steel is the softest steel, so very grey iron is the softest and most easily worked iron. Grey iron in which the matrix consists entirely of pearlite is the strongest of its kind, just as in steel we get the greatest strength with about 1 per cent. of carbon, while steel consists almost entirely of pearlite. But ordinary cast iron is very much more impure than steel, and the above analogies only strictly apply to pure cast iron. Mottled and grey cast irons may be considered as very impure steels containing graphite.

Silicon.—Silicon may exist in cast iron as a silicide of iron, Fe_2Si, but not as separate entity; the whole of the silicon, at any rate up to 4 per cent., appears to be in solid solution in the iron, forming crystals of the cubic system. As the shape of these crystals is not different from that of pure ferrite they cannot be distinguished microscopically from ferrite, and may therefore be termed silico-ferrite. They are, however, harder than ferrite. It has been already explained that silicon in cast iron induces the grey variety. Heyn suggests this is due to silicon preventing supercooling, and therefore lowering the temperature at which graphite can be separated. The separation of graphite is a function of time and temperature, and silicon will not prevent the carbon remaining in the combined form if the metal is not kept a sufficiently long time at a certain temperature. Silicon in cast iron may be said to act in three ways:—1. By inducing the separation of graphite in large flakes. 2. By inducing the separation of graphite in small grains, termed "temper graphite." 3. By uniting with iron and manganese to form silicides, which tend to induce a large crystalline structure and increases the hardness and brittleness in proportion to the amount of silicon present. It does not appear to be able to dissolve carbon, or to combine with it at ordinary furnace temperatures.

Keep has pointed out that white iron frequently does not give sound castings and that the blowholes lead to diminished strength; but that a small addition of silicon eliminates blowholes and produces sound castings, silicon protects the carbon from oxidation, and therefore prevents the formation of carbonic oxide and carbon dioxide. He further states that white iron shrinks more during solidification than grey iron, hence the addition of silicon diminishes the shrinkage. Baker points out that two other effects are produced by silicon, in addition to its power of separating graphitic carbon. In the first place, both the tensile strength and the hardness of carbon-free iron are increased by the addition of silicon, which acts like combined carbon in steel. Secondly, the size of the graphite is influenced by the judicious addition of silicon, since the graphite, obtained by the addition of silicon to a hard iron, is smaller in size than that which exists in an ordinary soft foundry iron, and the metal is therefore stronger and closer in texture.

With regard to iron free from carbon and other elements, except silicon, Baker found that the tenacity was increased by additions of silicon up to 4 per cent., after which it gradually falls. The elastic ratio gradually increases as the silicon increases from 0 to 4 per cent., which is an index of brittleness. The increase of elastic limit and tenacity is, however, obtained with loss of ductility, but provided the metal is well annealed, this reduction is small with less than 3 per cent. silicon, after which it becomes very great, and with 4 per cent. is almost zero. The alloys increase in hardness with addition of silicon, and after exceeding 5 per cent. become very brittle.

The effect of silicon on cast iron is to increase the hardness, but inasmuch as it induces the liberation of carbon as graphite, it acts as a softener and lessens shrinkage. By combining with oxygen it prevents blowholes. It increases the tenacity, but decreases the ductility.

Manganese.—The influence of manganese on the condition of carbon in cast iron is doubtless partly due to its having the power to combine with carbon

on its own account, therefore, to increase the quantity of combined carbon in the iron. Moreover, manganese has a special affinity for silicon and sulphur, which form silicide MnSi and sulphide MnS respectively, when the manganese is present in the quantities generally present in cast iron, that is, 2 per cent. and under. When it is present in larger quantities it forms, according to Garnet and Goutal, double carbides of iron and manganese. A certain proportion of the carbon is also combined with the iron to form free cementite. From the thermo-chemical researches of Troost and Hautefeuille there are strong grounds for believing that manganese forms with carbon and silicon chemical compounds of considerable stability, and these compounds are *exothermic*. Manganese has also a higher solvent power for carbon : by solvent is meant the capability of forming those indefinite solution compounds, truly chemical in nature, but readily passing from one form to another, and uniting in varying proportions to form compounds strictly limited by the law of definite and multiple proportions. Manganese evidently forms compounds strictly limited, as shown by the sharply defined crystalline form.

The relation of manganese to oxygen is important, as it prevents oxidation of iron when in the molten state, being itself more readily oxidisable and passing into the slag as a silicate of manganese. Hence, loss of manganese is liable to occur in re-melting pig-iron containing it. This slag-forming tendency of manganese tends to produce basic slags, which are favourable for the removal of sulphur, for the more basic the slag the more completely will the sulphur be removed in the slag and the less will be the amount left in the iron. Keep mentions a case where he put 2.6 per cent. of manganese into an iron containing 1 per cent. of silicon, and after keeping it in the furnace nine hours found the manganese was reduced to 0.6 per cent.

Tests by Keep show that manganese increases the shrinkage, and that an increase of 1 per cent. of manganese increases the shrinkage 26 per cent. This is doubtless due to the manganese keeping the carbon in the combined form. Manganese, as already stated, prevents blowholes. But this again will depend on the casting temperature. If the metal is poured too hot there will be external blowholes, and if poured too cold the blowholes will be found internally as well as externally. As regards hardness, an increase of manganese enormously increases it, and this is advantageous in producing a hard chill. Strong irons generally contain up to 1 per cent. manganese.

The general effect of manganese is to cause the carbon to remain in the combined form, and therefore increase the hardness and shrinkage; to prevent blowholes by combining with oxygen; to produce a hard chill; to unite with sulphur, and in this respect to lessen the hardness; to form a basic slag, and thus partially to remove sulphur and phosphorus; to produce a close grain, and, therefore, a strong casting; and to increase the transverse strength.

Sulphur.—Sulphur, even when present in small quantities, exerts a considerable influence on cast iron. But the proportion usually found in foundry irons is small, yet relatively small variations in sulphur content may entirely change the character of the iron. Sulphur generally exists in iron as a sulphide, and when manganese is present, as a sulphide of manganese. The former is readily fusible and decomposes at high temperatures, the consequence being that when the metal is slowly cooled from a high temperature a large proportion of the sulphur escapes as a gaseous compound, giving the metal a spongy texture. In the presence of manganese the sulphur appears to unite with that element in preference to that of iron, and as this manganese sulphide has a high melting point and a high dissociation point, the sulphur is not then liberated in the gaseous form, so that blowholes and redshortness are largely avoided. The tendency of sulphur in cast iron is to neutralise that of silicon. It acts in the same way as manganese in keeping the carbon in the combined form. Turner states that cast iron free from sulphur is apt to be too soft and wanting in strength and rigidity. For strong metal the sulphur should not be more than 0.07 per cent., and it is never advantageous to introduce more than 0.1 per cent. If we consider that other elements are present, such as silicon and manganese, each of which is capable of uniting with sulphur, we see how complicated the effect may be. This may account for the vagaries of sulphur in the different samples of iron and steel. For example, Turner obtained a compound having the formula, Fe_4SiS, by introducing sulphur into molten silicon pig-iron. This compound has a bright crystalline appearance, with large faces, and it is so brittle that it can be easily crushed in a mortar, yielding bright and light scales, which has led some observers

to suppose it to have been graphitic silicon.

It is generally observed that sulphur in pig-iron increases with an increase of combined carbon, but this increase is partly due to the diminution in the amount of silicon, which tends to remove sulphur and prevent it uniting with the iron. If pig-iron rich in silicon is melted in a cupola the product is found to be low in sulphur. A low temperature favours the retention of the sulphur and a high temperature its expulsion from the cast iron.

As sulphur exists in iron as a sulphide, which is moderately fusible, it is liable to retain the liquid form after the mass of metal has become solid. Now sulphur, like other metalloids in iron and steel, tends to segregate in the middle and upper parts of the cooling casting, but it is often found in pig-iron to be irregularly distributed through the mass. Stead found that sulphur in hematite with a little manganese was greatest in the middle portions, while in a pig with 2 per cent. manganese the sulphur was greater in the upper and outer portions. Moreover, when the sulphur in pig-iron is all combined with manganese, the carbon may separate out as graphite, and thus produce grey instead of white iron.

The general effects of sulphur on cast iron may be summarised thus :—In virtue of the formation of a fusible sulphide of iron, the cast iron becomes more fusible and presumably more liquid. In consequence of the inducement to form combined carbon the metal is harder. For the same reason the shrinkage is increased, since the amount of shrinkage closely follows the proportion of combined carbon and the hardness may be largely judged by a shrinkage test. As white iron is the most dense form of cast iron, sulphur therefore tends to increase the density. With much sulphur and in the absence of manganese and the prevalence of a high-casting temperature, sulphur may cause blowholes. Because of the high shrinkage the castings are liable to develop fractures. Because of the combined carbon sulphury iron produces a deep chill. In consequence of segregation, blowholes, and fusible sulphides, which produce inter-crystalline weakness, sulphur tends to diminish the strength of cast iron. The presence of sulphur tends to diminish the total carbon; but as the quantity usually present in cast iron is very small, this effect may be considered as negligible.

Phosphorus.—Phosphorus in pig-iron exists as a phosphide having the composition Fe_3P, which is equal to 15.6 per cent. phosphorus. In the blast furnace practically the whole of the phosphorus in the ore passes into the pig-iron. Phosphorus in pig-iron has little direct influence on the condition of the carbon. Both the carbide and the phosphide of iron are intensely hard, but Stead considers the carbide the harder of the two. On heating cast iron containing phosphorus to 900 degrees C., and cooling moderately rapidly, the phosphide passes into solid solution and is, on cooling, distributed between the newly-formed pearlite grains, and therefore behaves in a similar manner to steel free from phosphorus. When the carbon reaches 1.7 per cent. the phosphorus is thrown out of solution and exists as free phosphide. Phosphorus increases the fluidity of cast iron, and therefore renders the metal more suitable for fine castings. With much phosphorus the phosphide remains fluid after the rest of the metal has solidified, and being deposited through the metal makes the castings more brittle and more easily fractured by shock. This effect is so characteristic that it is possible to tell approximately the proportion which is present in a pig by the readiness with which a given grade will fracture when thrown upon a pig-breaker. The ready fusibility of the phosphide eutectic renders phosphoric irons unsuitable where the metal has to resist high temperatures, as in the case of ingot moulds and fire-bars. The presence of phosphorus lowers the percentage of total carbon, and this effect increases proportionately with the increase of phosphorus. The amount of carbon with 2 per cent. of phosphorus is probably not more than 2 per cent., so as regards carbon the metal is more like steel than cast iron. Now, the more steel-like the metal is the less is the tendency to form graphite, and the greater the tendency to form combined carbon. In this respect the influence of phosphorus acts indirectly towards the formation of combined carbon. For strong castings the phosphorus should not exceed 0.5 per cent., and when the amount exceeds 1.5 per cent. the iron is very weak. Probably no other element weakens cast iron as much as phosphorus, especially when present in large quantity. A moderate amount of phosphorus, while increasing the fluidity, will lessen the shrinkage.

The influence of phosphorus on cast iron may be briefly summarised as follows :—It makes the metal harder, whiter, more fusible, and fluid, weak, and more largely crystalline, it prevents blowholes, and is stated by Keep to enormously lessen the shrinkage.

Now, while the effect of each element on iron, when taken alone, has a specific influence, it must be remembered that some elements have directly opposing tendencies, and in certain proportions exactly neutralise each other, as, for example, silicon and sulphur or manganese. But there are two other most important functions which play an important part in forming the structure, and therefore the properties of cast iron, namely, *time and temperature*, as explained in the early parts of this paper. Now, if silicon and manganese were present in the neutralising proportions, the iron and carbon will not be left free to act alone, and we may get mixed crystals of iron silicon and manganese, graphite, cementite, and pearlite, all in the same cast iron, and the total effect will be a modification, due to the nature of the complex mixture. The temperature of casting, and the length of time a metal remains in a certain range of high temperature are, perhaps, the most powerful influences in determining the structure of cast iron, and hence its various properties.

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AMERICAN FOUNDRYMEN'S ASSOCIATION.

THE eleventh Convention of the American Foundrymen's Association opened in Cleveland, Tuesday morning, June 5. The address of the President, Mr. Thomas D. West, dealt with "The Need of Benefit of a Practical Education." Mr. West was rather severe in his criticisms of some tendencies in modern education which, in his opinion, are far from practical. In conclusion, he said :

"While much good has been accomplished by our Association, there is still greater work before us, but to do this properly we should have a much larger membership. It is to be hoped that this Cleveland Convention will result in giving an impetus in this direction. In justice to ourselves we cannot recede; we must enlarge and press forward. Can we say more in soliciting outside craftsmen to join us? The latch string is out, and 'Welcome' is emblazoned above the door, inviting fellow foundrymen to enter and become one of us.

"Education is our Association motto, and by making it as practical as possible we can do a great good in helping to make this world grow better. This Association and kindred societies will certainly have to labour for more practical methods of instruction if, as a people, we truly desire to develop good skill in our artisans, or to obtain the greatest comfort and happiness for the masses. This is a condition that can and should prevail throughout the civilised world."

The Secretary's Report.

The secretary-treasurer, Dr. Moldenke, read his report, which was as follows :—

In presenting a brief report of the activities of his office during the fiscal year just closed, your secretary begs to state that the affairs of the Association are in a satisfactory condition, its influence steadily rising, and its usefulness growing greater all the time.

The year has been one of exceptional activity in the foundry, but also so hampered by high-priced materials, poor deliveries, and economic troubles, that, on the whole, few foundrymen look back upon it with satisfaction. We may except only those who have so far specialised their work that the foundry end need only make part of the profit of the concern. These facts, peculiar as they may seem when taken in connection with the era of prosperity we are in, have been gathered by the voluminous and far-extending correspondence, as well as personal interviews during the year. No wonder that the foundry is so sensitive to all kinds of disturbances, and the layman regards pig-iron, which is without his knowing it the big item in the foundryman's bills, as the best barometer of trade conditions.

As a result of the reduction in the annual dues last year, the Association has slightly increased its membership, having exactly 300 members at the present time. Very strenuous efforts were made to obtain new members, both by correspondence and personal interview. The Association is well known in all parts of the world. Letters come from everywhere asking information, advice, and even plans and estimates for new foundry ventures. Everything possible is done to oblige the correspondents, and wherever possible the difficulties of engaging in new enterprises pointed out, in order to save loss on the one hand, and destructive competition on the other.

Perhaps the best criterion of the value of the Association is the fact that other countries are following our methods with profit to themselves. Again, many local associations, organised for a variety of purposes, find it beneficial to discuss foundry problems of a technical nature at their meetings.

The American Foundrymen's Association has been signally recognised by the election of your secretary as an honorary member of the British Foundrymen's Association, and further by his appointment on the National Advisory Board for testing fuels and structural materials recently created by the President.

The Government, through its Bureau of Standards, has now formally taken over our standardising bureau, thus closing a chapter in our life which has proven of great value to scientific founding as well as the iron laboratory. To our President, Mr. West, is due the credit of its inception and nearly all the labour of maintenance. The Case School, where we meet once at this Convention, through its Professor Smith, also has contributed largely to the success of this undertaking, now well known throughout the civilised world.

With the taking over by the Government of this work, it will be enlarged to include the steel industry, and possibly go into further branches of interest to foundrymen in general. We hope for a wide field and all possible success in this direction.

The receipts and expenses for the fiscal year, are as follows:—

	Dols.
Received for dues, etc.	1,045.18
Standardising bureau	495.72
Total	1,540.90
Disbursed for salaries	894.62
Printing	92.02
Transactions	154.25
Postage	233.00
Sundries	23.30
Total	1,397.19

leaving a balance in the treasury of $143.71.

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THE business of William Dawson & Sons, of Otley, Yorkshire, has been turned into a limited liability concern, under the style of Wm. Dawson & Sons (Otley), Limited.

MESSRS. JOHN LANG & SONS, engineers, of Johnstone, have lately placed contracts for the erection of additional buildings which will more than double their present extensive works.

A COMPANY has been formed in London by Messrs. Brown, Boveri & Company, which will take charge of the interests of the Swiss Company in Great Britain, the Colonies, and various other countries. The English Company has purchased the business of Witting, Eborall & Company, Limited, and will carry it on as a part of the business of Brown, Boveri & Company, Limited.

AN AWKWARD CORE.

By J. SHAW.

HAVING an acid egg, weighing 4¾ tons, to make some time ago, I thought a general outline of the method might present some fresh features to your readers. This casting, as will be seen from the sketch, is 9 ft. 6 in. long by 3 ft. 1¾ in. diameter in the barrel part, contracted at each end to 13 in. diameter, the metal in the thinnest place being 2¼ in. This vessel is used as a reservoir for sulphuric acid, the acid being forced through one of the branches to chambers at different heights by means of pneumatic pressure, which comes into the egg through the second branch shown, the third branch being used to fill the egg by.

Having a pattern the right diameter, and about the length of the central part of the casting, we screwed a branch at each end of the same diameter as the egg ends, and completed the outline by means of skeleton pieces A, sawn out of 1½ in. timber, and screwed to both pattern of branches, this forming a strong job. The flanged branches we formed with cores, and this completed the pattern.

The moulding presented no great difficulty, the pattern being rammed up in sand and dried, but the core called for careful thought.

Owing to the action of the acid, no chaplets could be used to hold the core down, and the whole lift (about 16 tons) had to be held down at the ends of the core bar. Besides the fear of bending in centre when the lift came on, the much larger diameter of the core in the barrel part (13½ in. on each side of the bar) was a weak place.

The method decided upon was as follows :—

A strong 11 in. core bar B was selected, and on this, for the large part of the core, was built a larger bar in the following manner :—Five round plates C were cast, with a hole in the centre to just clear the 11 in. bar and four keyways 1⅛ in. wide, as shown in sketch C. Two of these plates had also prods to carry the extra loam at the tapering ends and a series of slot holes 1½ in. from the outer edge to hold the hook bolts that fastened the slabs. These slabs D (16 in number) were cast long enough to allow loam at each end and about 6 in. wide by 1 in. thick, each had a slot hole at both ends and a stop to meet the end plates C¹. The round plates C and C¹ were slipped over the core bar B, the first one wedged tight by means of the

four wedges round centre hole. A slab D was laid on top, and the other plates C and C¹ were divided in the length of D, and also wedged to the centre bar in this position, taking care that the stops at each end of the slab fit tight against the plates C¹. A hook bolt at each end of D, with the hook put in the slot at the outer edge of C¹, fastened the slab and end plates C¹ firmly together. The remaining 15 slabs were fastened in the same manner, and formed a rigid barrel for the large part of the core, allowing 1½ in. each side for loam and straw. Before putting the last slab in place, the whole space between the small bar B and the newly-formed large bar was filled with dry ashes to prevent a large accumulation of gas at this point. The bar being now ready, the prodded end plates C¹ were stuffed with old coke, and the core roped and struck up in the ordinary manner. In the sketch I have purposely not shown anything but the core bar in the casting, the rope, loam, etc., would only confuse.

In order to test if the core lifted at all, we obtained permission to place a rod of cast hematite, 15 in by $\frac{3}{8}$ in. diameter, one end resting on the core and the other coming through the top box. A piece of flat iron was placed on either side of this rod, just level with the top, so that any upward movement of the core would show at once. It was found, after casting, that the rod was $\frac{1}{16}$in. higher than the flat irons, but whether this small amount was due to lift or expansion of the rod is of little moment.

It might be thought this barrel would be difficult to get out of the casting, but this did not prove the case, a smart blow with a tup on the end of the 11 in. bar loosened the wedges, and the centre bar was withdrawn; the plates C and C¹ were next broken, and the slabs D could then be drawn out. The open sand plates C have to be cast for each core, but made from a pattern, these cost but little to be renewed.

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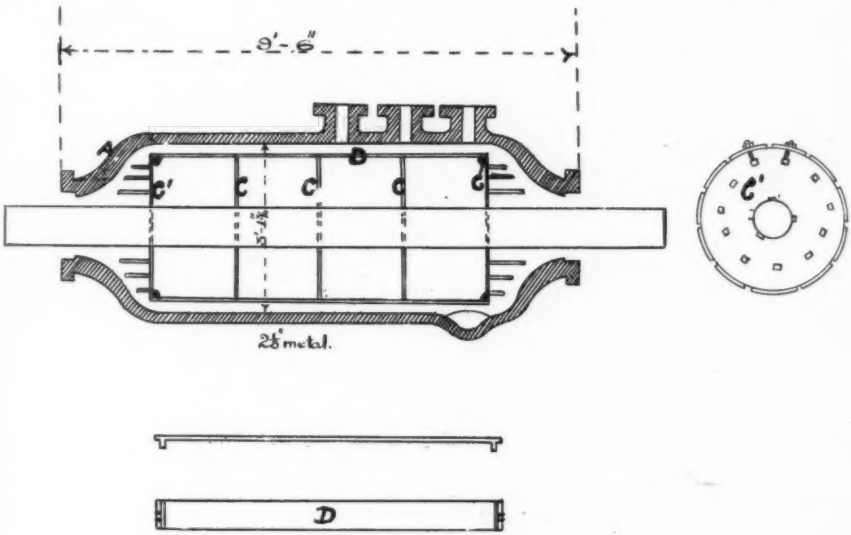
RAINE & COMPANY, LIMITED, 15, Grey Street, Newcastle-on-Tyne, have appointed Mr. H. B. Sparrow, of 65, Fenchurch Street, E.C., as their London agent.



A FIRST and final dividend of 2s. 2⅓d. in the £ has been paid by Mr. E. C. Donat, mechanical engineer, who traded as Donat & Company, Manchester.

THE HOLWELL IRON COMPANY, LIMITED, of Asfordby, Melton Mowbray, lately secured contracts to supply cast-iron pipes and special castings to the Gas Light and Coke Company, London; cast-iron pipes, well cylinders, valves, and fittings, to the Hambledon Rural District Council; and cast-iron pipes and special castings, for the Brixham Water Works.

NEW TESTING MACHINE.

We illustrate a machine which has recently been put upon the market by Messrs. Samuel Denison & Son, Limited, of the Hunslet Foundry, Leeds. It is intended for the use of ironfounders, and the makers claim that a series of experiments in the mixtures of iron will, by the help of this machine, effect large savings in the cost of castings. It has been demonstrated over and over again that a considerable amount of money may be saved by using less costly brands of pig-iron than are commonly supposed to be indispensable to obtain certain results.

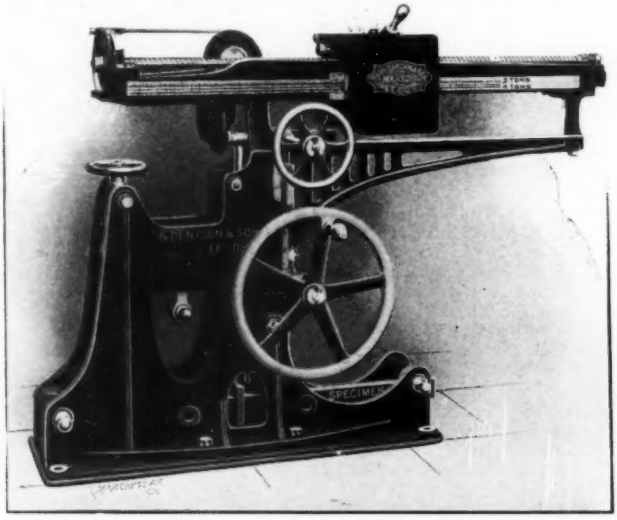


Fig. 1.—Transverse Testing.

Some firms are using most expensive irons in the hope of producing castings that will give a high transverse test; but indifferent results are often arrived at, whereas with a better knowledge of the various brands of pig-iron—which can only be known by actual testing—it is possible, at a considerable reduction in cost, to produce a much stronger casting.

The machine, as shown in Fig. 1, enables a transverse test for cast-iron sample bars 2 in. by 1 in., placed edge upwards under bearings 3 ft. apart, to be made up to two tons capacity. It may also be arranged for 50 cwts. capacity. The machine also tests bars 1 in. square under bearings 1 ft. apart. There are two turned steel pins, which are movable so as to give the length of bearing required. The second illustration, Fig. 2, shows the machine making a test in tension. A simple casting, $\frac{1}{2}$ in. square, with two tab ends, and holes cast in, is the sample to be tested. It is secured to the second lever of the machine with a pin, and to the frame of the machine by one of the lower pins removed to that hole. The capacity of the machine for this tensile test is 4 tons. It is always in equilibrium, whichever kind of test is wanted. The machine carries an accurate extension gauge. The steelyard carries two graduations, the upper one being for transverse testing, and the lower one for tensile testing. There are no loose weights. The poise weight is propelled along the steelyard by means of a screw operated by the smaller hand wheel; the larger hand wheel, on being turned to the left, raises the whole superstructure of the machine, and so pulls up at the specimen. The horizontal hand wheel shown on the left-hand side in the illustrations is for getting a level position of the lever, by means of a spirit level which is carried thereon, when a tensile test is to be made. After each test, the poise weight can quickly be brought back again to zero by its handle, which disengages the nut from the travelling screw.

THE BENEFICIAL EFFECTS OF ADDING HIGH GRADE FERRO-SILICON TO CAST-IRON.*

By Alexander E. Outerbridge.

A problem has long engaged the attention of metallurgists, viz.: how to economically obtain from one suitable for different kinds of castings ranging, let us suppose, from those requiring high chilling iron such as chilled cast-iron car wheels, or, from castings of high tensile and transverse strength, to small castings requiring extreme softness and ductility, in which great strength is not looked for. The wide variations in physical properties of cast-iron are due to two combined causes, chemical composition and rate of cooling from the liquid state. Strength and softness are antagonistic qualities rarely found united.

It is the universal custom to pour car wheels from special mixtures having suitable chilling property, and stove plates are poured from entirely different mixtures in different cupolas, and it has but little chilling property; but the modern metallurgist or general practitioner is daily called upon to provide metal melted in one cupola and one heat, suitable for a great variety of castings, and requiring, if the best results are desired, wide variations in physical properties as well as chemical constituents. The method adopted by the author many years ago, and which is, no doubt, practised by others to meet these varying requirements in a thoroughly practical manner, has been to group all the small work for the day, needing soft ductile iron, so that it will be cast at the beginning, or near the beginning, of the run of iron from the cupola, which is, of course, charged with the required amount of the softest grades of iron; the proportion of silicon in such mixtures approximating 2½ per cent. This is followed by a medium grade of iron, calculated to contain about 1.9 per cent. silicon, giving a product suitable for miscellaneous castings of

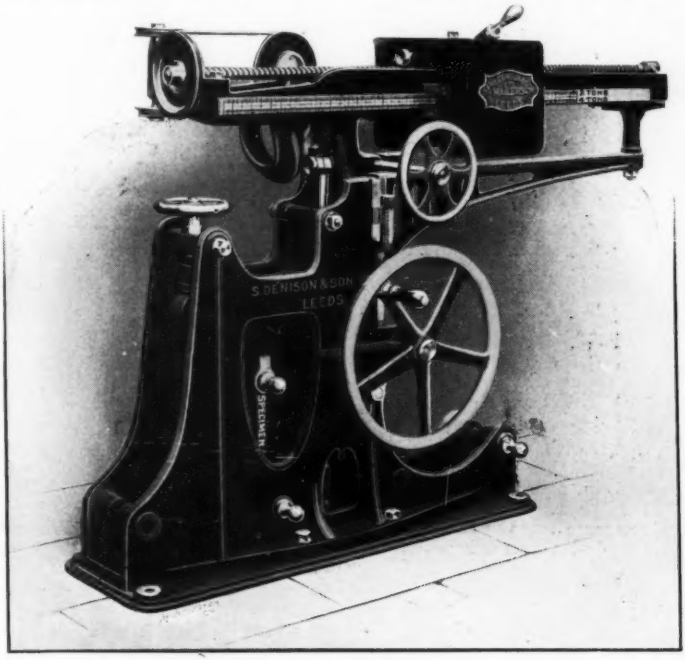


Fig. 2.—Tensile Testing Machine.

* Paper presented before the American Foundrymen's Association.

medium weight and thickness, and capable of being machined readily, but not too soft to give good wearing service; this, again, is followed by strong iron mixtures intended for large and heavy work requiring close grained texture and usually high tensile and transverse strength. The strong iron may have as little as one-half of 1 per cent. of silicon and may possess high chilling property. The transverse strength of the soft iron (2½ per cent. silicon) when cast in bars 1 in. square section and 15 in. long, broken in the middle with supports 12 in. apart, one ranges from about 1,900 lbs. to about 2,200 lbs., and the tensile strength per square inch of the same bars, when turned and pulled on a machine, having automatically adjusted grips to insure a perfectly straight pull while the piece is being strained, averages ten times the transverse stress, or, 19,000 to 22,000 lbs. per square inch.

The medium iron (1.9 per cent. silicon) averages 2,500 lbs. transverse strength and 25,000 lbs. tensile strength per square inch cast in the same size bars and tested under the same conditions. The strong iron should exceed 3,000 lbs. transverse strength and 30,000 lbs. tensile strength of the same bars in the regular daily work.

"Special castings" have been made in the foundry of William Sellers & Company, Incorporated, which have united the two antagonistic properties of high tensile strength with softness and ductility in a remarkable degree. Tensile test of bars ½ in. square section (being the same thickness as the castings) formed in the same mould with the castings, and attached thereto, have shown, when turned and pulled on a 100,000 lbs. hydraulic testing machine, extraordinary tensile strength, viz.: 40,535 lbs. to 44,565 lbs. per square inch. These are believed to be the highest records ever noted for soft cast iron, if, indeed, they are not the highest for any kind of cast iron melted in a cupola.

It is, of course, impracticable to obtain a perfectly sharp dividing line between the soft iron, medium iron, and strong iron charged in a cupola and in the molten metal withdrawn therefrom, for it is impossible to prevent a portion of the product, if the composition is varied during the charging of the cupola, from being to a certain degree variable, so as not to be accurately predictable as to its composition and physical properties in individual taps at the time when the metal is tapering off from one grade to another.

To overcome this uncertainty it is customary, in the foundry already named, to arrange the daily work so as to have a certain number of castings serve as "buffers," *i.e.*, to take iron that is intermediate between the different grades charged in the furnace, and this method has proved very satisfactory. The buffers are usually castings that require but little machining and in which a considerable variation of composition of the metal is permissible. There are always plenty of such castings made in every foundry each day.

To supplement this routine method by a simple and cheap process of varying the chemical constituents and physical properties of molten iron after it has been tapped from the cupola and removed from the source of heat, is a desideratum devoutly to be wished for, and many efforts have been made to perform the trick. The prime difficulty is found in the fact that the melting point of cast iron is lower than that of nearly all of the metals or metalloids that are suitable for the purpose. For example, the addition of wrought iron or steel to cast iron increases its strength and chilling properties. It is a common practice to add steel in the cupola for this purpose, but, if the attempt be made to incorporate steel or wrought iron in the form of chips or small pieces in a ladle of molten iron withdrawn from the source of heat supply, it will be found unsatisfactory, for the reason that the melting point of steel is too high to permit of a sufficient amount of it to be dissolved and diffused throughout the molten iron to effect a radical change in physical property without causing dull iron to result therefrom.

The element, silicon, is practically the governor that determines the degree of hardness of cast iron, therefore the value of a single and inexpensive process that would enable the intelligent founder to control the proportion of silicon in any individual ladle of molten iron drawn from the melting furnace would be at once apparent, especially in foundries where miscellaneous castings, ranging in size from small pulleys, with rims ¼-in. thick, bed plates for various machines, hydraulic cylinders, and the like, sometimes weighing many tons and of various thickness, up to 1 ft. or more, as is the daily practice in many foundries.

In the year 1886, the author made many experiments in this direction, using the richest grades of ferro-silicon then obtainable, containing from 10 per cent. up to 18 per cent. of silicon, by adding the alloy in small lumps or in powder to

ladles of molten iron, but found that the metal would not dissolve a sufficient quantity of the alloy to greatly change the proportion of silicon and thus to produce a marked increase in softness of the iron without appreciably affecting the temperature and fluidity of the molten iron. Pre-heating the alloy was the next logical step tried, with an improved result, but it was soon ascertained that the inconvenience and cost of heating the alloy red rot would militate against its general usefulness. At the same time, it was found that the addition of a small amount of ferro-manganese containing 80 per cent. manganese (then a commercial product) accomplished the object sought in car-wheel mixtures in a totally different manner by changing the condition of the carbon and without the necessity of heating the alloy. Therefore, the tests with ferro-silicon were discontinued. In recent years electro-metallurgy has made giant strides, and it is now possible to obtain commercially pure silicon (over 98 per cent. pure) and ferro-silicon of extreme richness, ranging from 50 per cent. to 80 per cent. silicon, or over. This fact caused the author to again take up the experiments of adding silicon to ladles of molten cast iron, where he had left off in 1886. A quantity of 98 per cent. silicon was obtained in large lumps, this material resembles in appearance 80 per cent. ferro-manganese, but is very much lighter in weight, bulk for bulk, the specific gravity being about one-third that of 80 per cent. ferro-manganese and less than one-third that of cast iron. Many tests were made with this new material, which resulted in failure, owing partly, no doubt, to the very high melting points of silicon (about the same as steel) and partly to its levity, which caused the powder to float to the surface of the molten iron if sprinkled into the ladle, or to simply cake if tested to the bottom. When an alloy of silicon and iron containing 50 per cent. of silicon was used, however, a very different result was noted. This material was obtained in the form of coarse powder and was sprinkled into the molten iron as it was tapped into the ladle. Instantly the surface of the molten iron became "alive," as the workmen aptly expressed it; a rapid circulation of the skin of oxide, which always forms on the surface, was noticed, moving in circles like ripples from the centre towards the edge of the ladle; this lively movement continued until the metal was poured and the same movement was noticed in the gates and risers of the castings. The usual test bars were poured both from the treated metal and from the same iron untreated. "Chill test pieces" were also poured into heavy iron cups, which serve by the extremely rapid cooling of the small chill test bars to magnify any chilling property just as a microscope magnifies any minute object. Few practical founders are aware of the fact that there is a very great difference in the chilling property of soft foundry irons, as the metal if poured in a sand mould, even in very thin section, does not show an appreciable chill, yet it does show the effect of such concealed chill under the machining operations of drilling, planing, or milling, for the reason that particles of iron containing combined carbon may, under such conditions, be distributed throughout the castings, which are too minute to be seen by the naked eye, but destroy the cutting tools. The chill cup test is in effect a physical analysis of practical value which enables the foundry foreman to know the character of every ladle of iron, small or large, before he pours his metal. The little tapered bars poured in the cups become solidified immediately, are then turned out, cooled in a bucket of water, and broken. Such tests are poured from every tap, broken at once, and placed in a row for the foreman's inspection.

The chill cup tests of the treated and untreated iron in the foregoing experiment showed at once that the small amount of 50 per cent. ferro-silicon added, viz., ½ lb. in a 200-lb. ladle, had dissolved in the iron, wiping out the chill in the metal almost completely. The regular transverse test bars when broken showed two very interesting features, one of which was anticipated, the other unexpected. The metal of the treated bars was much softer in appearance, as was already indicated by the chill cup tests, but, instead of being weaker, the treated bars were all stronger than the untreated bars. In other words, increased softness and increased strength (too usually antagonistic properties) were here combined. The castings poured from the treated metal were small pulleys having rims about ¼ in. thick, that are ordinarily turned at a speed of 25 ft. a minute. The treated pulleys were turned without destroying the cutting edge of the tool at 40 per minute, as shown by memoranda furnished by the lathe operator.

Another interesting observation is that a given increase of silicon, say one-quarter of 1 per cent., imparted to molten iron in this manner is more effective as a softener than an equal increase of silicon

imparted through the cupola in the charging of the iron, which any increase of silicon in the cupola always causes a corresponding decrease in strength of the metal. The *rationale* of the increase in strength with increased softness discovered in these tests is, in all probability, to be found in the deoxidation of the iron by the silicon added in its nascent condition. It is now quite generally believed that there is a small amount of oxide of iron dissolved in all iron melted in a cupola (notwithstanding the high percentage of free carbon) and that this oxide is a weakening element. Silicon has a strong affinity for oxygen and presumably seizes upon the oxygen of the dissolved iron oxide, liberating the iron, the silicon (oxide of silicon) thus formed having specific gravity of only 2.41 as compared with 7.15 the sp. gr. of cast iron, rises to the top, thus accounting for the two facts herein noted, viz., the rapid circulation of the skin on the surface of the molten iron in the ladle, and the apparent slight loss of silicon when added in the alloy. The reason why an alloy of iron and silicon, rich in the latter element, dissolves and diffuses throughout the molten mass, while pure silicon will not, is probably owing partly to its relatively high specific gravity (over 6) and partly to the fact of already being alloyed with iron which melts and acts as a diffusing vehicle, enabling the silicon to become incorporated with the molten iron. The action is very similar in this respect to that of manganese in the 80 per cent. ferro-manganese already spoken of.

Not desiring to extend this paper to undue length, details of many similar tests are omitted which, it may be said, have resulted in the practical adoption of this method of treating iron in the ladle in the foundry of Wm. Sellers & Company, Incorporated, as a ready and reliable means of producing very soft and, at the same time, strong iron for small castings from metal of medium grade which would not otherwise be so well adapted for the purpose.

The 50 per cent. powdered ferro-silicon used costs about 2d. per lb. at the present time, but, as the quantity required to produce the desired result is so small, viz., about ½ lb., or less, to 100 lbs. of iron, the cost is really trifling, and is far more than counterbalanced by the fact that cheaper grades of pig-iron may be used in the furnace. Added to this is the great practical value of being thus able to control the product absolutely and to vary the character of the metal in regard to softness, or machining quality, while at the same time increasing the strength and ductility of individual ladles of molten iron drawn from one common source.

Appended hereto is a small table of a few tests of treated and untreated bars of soft and medium grades of iron all showing gains in strength ranging from 2 3-10 per cent. to 26½ per cent., and in deflection of the bars from 7 14-100 to 31 per cent., while the increase in softness was very marked indeed. It is hoped that these few records may prove interesting and valuable to founders.

Results of Tests of Ferro-Silicon in Ladles.

Remarks.	Breaking strain.	Deflection.	Resilience.	Shrinkage.
Oct. 10, '05	Lbs.	In.		In.
Si. addition.	2,265	.120	45.30	.192
(½lb.) Hand Ladle	2,155	.112	40.09	.191
Gain	110	.008	5.21	—
Oct. 11, '05	2,215	.137	59.51	.182
(½lb.) Hand Ladle	2,165	.124	44.60	.185
Gain	50	.013	5.91	—
Oct. 14, '05	2,600	.152	65.79	.196
(½lb.) Hand Ladle	2,055	.116	39.18	.188
Gain	545	.036	26.61	—
Oct. 15, '05	2,330	.143	55.45	.183
(½lb.) Hand Ladle	1,893	.110	34 60	.183
Gain	437	.033	20.85	—
Oct. 16, '05	2.210	.124	45.54	.183
(½lb.) Hand Ladle	2,120	.112	39.44	.185
Gain	90	.012	6.10	—
Nov. 13, '05	2.370	.139	54.76	.186
(1 lb.) 200lb. Ladle	2,050	.118	40.19	.184
Gain	320	.021	14.57	—
Nov. 21, '05	2.178	.128	46.34	.188
(1 lb.) 200lb. Ladle	2,000	.119	39.60	.182
Gain	178	.009	6.74	—

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W. & T. Avery, Limited, of Birmingham, are establishing a factory in the United States, which will be run as a separate concern under the name of The Avery Scale Company. The Company recently opened a branch at 282, High Street, Stratford.

The new engine sheds of the Great Western Railway Company at Old Oak Common have now been completed. The total area of the new buildings covers upwards of 215,000 square feet. The repair shop is 195 ft. by 101 ft., and the fitters' and machine bay is 195 ft. by 45 ft. The shop is equipped with an electrically-driven overhead crane, of 30 tons capacity, and operated by electric motors.

MALLEABLE CAST IRON, ITS MANUFACTURE AND ITS PHYSICAL PROPERTIES.*

WHEN speaking of malleable cast iron, we understand by that term an iron casting made malleable by a process of annealing. In some branches of engineering we rarely meet with this interesting product of metallurgy, while in other branches—the construction of conveying machinery and agricultural machinery, etc.—malleable cast iron is one of the most important materials the engineer has to deal with, and an intimate knowledge of the physical properties and peculiarities of this metal is therefore highly desirable.

In a modern technical reference book I find this definition on modern malleable cast iron :—

"Malleable cast iron is the name given to castings made of ordinary cast iron which have been subjected to a process of decarbonisation, which results in the production of a crude, wrought iron. The castings are made in the usual way, and are then embodied in oxide of iron, etc." Furthermore, it states : "It only requires proper mixtures and proper annealing, coupled with care in other particulars, to make malleable castings that will weld on itself; that will draw out to a knife-edge on an anvil under a hammer: that will temper and cut soft iron like a cold chisel."

This, I think, is too good to be true for ordinary malleable castings, and I have not found any authorities, few as they are, to be as enthusiastic as that.

The present generally accepted theory of the malleable cast iron process is to decarbonise the metal by some oxide, which will impart a portion of its oxygen to the carbon in the metal at a red heat, forming carbonic oxide, which is given off, thus extracting the carbon. The oxidising re-agents usually employed are rolling mill scale and red hematite iron ore.

It is important that this material should be as free as possible from sulphur, which is the most objectionable substance in malleable cast iron. The theory as expressed above does not, however, seem to cover the field, as malleable castings are now produced without any decarburising material, the hard iron castings being packed in fireclay or sand instead of rolling mill scale or hematite ore. For small castings this treatment gives tolerably good results, but for heavier casting tests and analyses show an inferior product. It is already stated that malleable cast iron is produced from hard or white castings, and we will therefore consider the means by which this important property is secured.

The furnace most commonly used in malleable foundries is of the reverberatory type, as this furnace has the great advantage of melting the charge without the fuel coming in contact with the metal. These furnaces vary in details of construction, but the accompanying illustration will give an idea of the general arrangement.

The ash pit is enclosed and contains the air inlet from the blower. The grates are charged (commonly with good bituminous coal) through side doors, which are hermetically closed except at the time of charging. The flame passes the bridge, and in some furnaces there is given an additional supply of fresh air forced through a number of small pipes and in the direction the gases travel. The hearth is slightly inclined towards the bath where the molten metal collects, and on this hearth is carefully piled up the charge to be melted. The roof immediately over the hearth is composed of a number of built-up arches which are handled by a small travelling crane over the furnace. In charging the furnace these arches are removed, and when again placed in position all cracks or joints are closed with fireclay. A little above the high level of the bath are located on each side of the furnace rather small rectangular openings. Through these the events inside the furnace are observed, and through these the wrought iron bars are inserted for skimming off the slag and for "rabbling" or puddling the molten metal until the desired quality is reached. Beyond the bath is the "choke," and finally the smoke stack, about 75 ft. to 100 ft. high. At the bottom of the bath, on each side of the furnace, are located the tapping holes closed by a clay plug as in a cupola. The day's work is started by charging the furnace with pig-iron, wrought iron, scrap, or old steel rails in such proportions as is deemed desirable for the castings to be made from the charge.

The pigs and rails are placed in layers somewhat diagonally so as to permit the flames to circulate freely through the mass on its way over the bath towards the smoke stack. After the charge is placed in the furnace the "bungs" or sectional arches are placed in position, all openings closed and the fire started. Five to ten

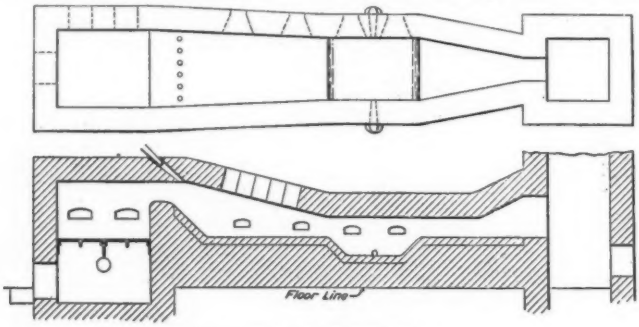
* Paper read at the April meeting of the Scandinavian Technical Society by Mr. G. A. Akerlind.

tons is usually the charge, according to the size of the furnace.

During the process of melting, which takes three to four hours, the grate surface is kept even to prevent cold air from entering the furnace, and when the charge commences to melt such parts as show a tendency to bake together are separated and led towards the bath, where the slag formed is skimmed off so as to present a clean surface of the molten metal to the flame in order to get the full benefit of the heat. After the charge is melted down the bath is vigorously "rabbled" or "boiled" to insure a thorough mixture and to reduce the percentage of silicon to the desired point. This point is determined by dipping out a sample which is rapidly poured into a cast iron mould, quickly cooled and broken. If the fracture indicates the presence of graphite carbon the "rabbling" is continued until a sample is procured whose fracture shows the desired composition or state of the metal. The moulders are now ready with hand ladles to carry off the metal to the flasks near by, for not only does the metal cool very rapidly, but chemical changes take place in the bath and everything has, therefore, to go with alacrity and dispatch. The tapping goes on from both sides of the furnace at the same time, and within about 30 minutes the whole charge is emptied and the furnace is allowed to cool down to receive a new charge.

The castings are removed from the flasks, the sprues and vents are knocked off, and all cores cleaned out. The metal is now almost as brittle as glass, and some care has to be exercised in its transportation to the annealing house. Here castings of similar weight and sections are grouped together and carefully "packed" in cast-iron boxes or frames varying in size to suit the articles to be annealed. The first one of these frames is placed on a cast-iron plate resting on two blocks in such a manner that the prongs of the hand charging machine can enter under. The pieces to be annealed are now placed so that they may be completely surrounded by the packing material (rolling mill scale or red hematite ore), and care is taken that some parts of the castings project over the edges of the box, in this way forming a guide for the next section.

A pile of about 5 ft. high is formed in this manner, and, when completed, removed by the charging carriage to the annealing furnace, where the piles are placed in rows so as to allow the flames from the fire-grate free play. The opening of the annealing chamber is finally bricked up tight and the fire started. These annealing furnaces are arched



REVERBERATORY FURNACE.

chambers about 7 ft. high by 12 ft. deep and 8 ft. wide, with canals in sides and under the floor so arranged as to convey the flames and the hot gases evenly through the rows of piles, and thus produce an even temperature. Natural draft is used, and the firing carefully moderated during the whole period of annealing, from two to six days or more, depending on the character of the castings.

The temperature is brought up to a bright cherry red or about 1,800 degrees Fahrenheit. The furnace is provided with sight holes for observation, and the blue flames at the joints of the boxes give an indication of the process going on inside where the combined carbon leaves its union with the iron to combine instead with the oxygen, in turn loosened from its combination with iron in the ore or scale, and forming a new combination carbonic oxide or dioxide, the gas producing the blue flames before referred to,

After the furnace is sufficiently cooled down the temporary brick wall in the opening is removed and the piles taken out by the charging carriage and placed on the floor, where the now annealed castings are taken out and placed in the rattlers for cleaning. If the castings are small and of delicate construction they are cleaned by being placed in wooden vats containing a weak solution of sulphuric acid and "pickled." To neutralise the acid after the pickling process, these castings are finally washed in lime water. After the annealed castings leave the rattlers they are carefully examined for cracks or other defects, and if sprung out of shape they are hammered or forced by hydraulic power to the correct shape. For such parts as are produced in great quantities steel dies are made and placed in a drop hammer. The annealing casting is then placed on the die, and one or two blows will insure its correct form. It may here be mentioned that nothing is gained by heating a malleable casting before hammering or forcing it. A temperature of 50 to 100 degrees Fahrenheit seems to be satisfactory.

I have endeavoured to review the manufacture of malleable cast iron in its different stages, and I will now attempt to review some points which have a more direct bearing for the practical engineer or draughtsman in considering malleable cast iron as a material of construction.

The tensile strength of malleable cast iron varies between 40,000 lbs. and 50,000 lbs. to the square inch, with an elongation in 6 in. of about 6 per cent. to 1 per cent., and a reduction of area of about 3 per cent. to $\frac{3}{4}$ per cent. respectively. This, of course, for a specially prepared test piece with symmetrical form. Let us remember that cast iron has a tensile strength of about 20,000 lbs. to 30,000 lbs. to the square inch, and is therefore about half as strong as malleable cast iron. This, however, only for tensile strength. For compressive strength cast iron is again the stronger of the two, and compares very nearly with steel. The position of a casting in a machine is oftentimes such that the definite stresses are very difficult, not to say impossible, to determine; and the engineer is here left to his own judgment, based on experience or the precedence of similar cases. If only lightness is the object for using malleable cast iron in place of ordinary grey cast iron, it is customary to make a reduction in weight of 30 per cent. to 40 per cent., sometimes more. The ductility of the malleable casting very readily permits the driving of rivets, which, as we know, cannot so readily be done with grey cast iron.

While white cast iron shrinks a great deal more in the flask than grey cast iron, and as the sections of malleable castings invariably are lighter than is the case in a similar casting of grey iron, fractures are very common, and it is therefore one of the designer's very first considerations to so arrange and distribute the metal as to meet these conditions. In pieces of an elongated shape, the stiffening ribs ought to extend lengthways so as to produce as little resistance as possible to the contraction of the metal at the time of solidification in the flask. If this be not possible, the moulder provides a "crush core" with the exterior surface made of core sand in the usual manner, but whose interior is filled with crushed coke. This core barely stands handling, and when the metal solidifies in the flask it is crushed by the retarding casting and thus prevents shrinkage cracks. At other times a certain corner or junction of ribs in the casting will be found cracked. In order to prevent this a small piece of cast iron (chill) is embedded in the sand at this critical point, and the metal will cool here more quickly than elsewhere, and thus fortify this particular point, although it may happen that some other part of the casting will be found fractured instead, and in many cases the locations and the shape of strengthening ribs in the casting have to be altered until a casting is procured free from shrinkage cracks. Sometimes such defects do not appear until the casting is annealed, which, of course, entails a greater loss than if the casting had been scraped before entering the annealing furnace.

In conclusion, let me summarise the points I would like to emphasise regarding the designing of malleable cast iron details.

1. Endeavour to keep the metal in the different parts of the casting at a uniform thickness, depending on the size and weight of the casting. If a small casting of, say, 10 lbs. weight $\frac{1}{4}$ in. metal is about the practical thickness, $\frac{5}{16}$ in. metal is about right for a casting of 15 lbs. to 20 lbs., and $\frac{3}{8}$ in. to $\frac{7}{16}$ in. or $\frac{1}{2}$ in. for castings of over 40 lbs. For commercial reasons the demand for light malleable castings sometimes forces the designer to give such dimensions for thickness of metal in his casting that the foundry cannot make it successfully, or else the manufacturer will insist on a price per pound that will protect him for the extra expense in making it and the loss due to a high percentage of cracked castings.

These losses sometimes amount from 10 per cent. to 20 per cent. It is, therefore, generally better policy to modify the design to suit the foundry, although, on the other hand, these same commercial interests on your side have to be guarded as those prompting the foundry man to insist on a heavy, easy casting.

2. Always endeavour to avoid sharp junctions of ribs or parts, and if the casting is long—say, 24 in. or more—bear in mind the ends should be made of such shape as to offer as little resistance as possible to the contraction of metal when cooling in the mould.

If called upon to inspect malleable castings as to strength, it is customary to break it with a sledge or under a "drop," and the difficulty of breaking it and the appearance of fracture forms the basis of opinion. A "good" casting will be found a pretty tough proposition to break. A fracture will show a distinct "skin" like wrought iron, while the interior is finely granulated, of a dark bluish colour, without metallic lustre. A "bad" casting is comparatively easily broken, does not show the skin, but does sometimes a very dark bluish colour, or in other cases a dark grey cast iron fracture. This is generally attributed to "poor annealing," but, as previously pointed out, if the metal in the furnace at the time of pouring does not have the right composition the resulting casting cannot be annealed. To guard against this it is sometimes practical for important castings to provide a small extension on a chunky part of the casting, where the chilling effect of the moulding sand would be least and so break off this extension. The fracture will then show whether the metal is of the proper nature for annealing or not. It should be remembered, however, that there is such a thing as over-annealing; but in the present busy time this is hardly likely to occur very often.

As for pattern-making, it may be mentioned that the common shrink rule, $\frac{1}{8}$ in. to 1 ft. longer than the ordinary rule, is used. Malleable cast iron shrinks more in the mould than grey cast iron, but in the annealing process a slight swelling takes place.

The first pattern is made of wood, and from this the foundry patterns are made of aluminium, to which metal we are greatly indebted for the present growth in the malleable foundry business. Without aluminium patterns heavier castings could not be made economically, as the old-fashioned brass patterns required two or more men to handle them. A pattern shop in a malleable foundry is nowadays a far more comprehensive institution than formerly. The wood-working department is still there, but in addition a small foundry for the aluminium castings and a machine shop with planers, shapers, lathes, and drill presses, etc., will be found. As in most foundries the foreman pattern-maker represents a great deal of the "brains" of the establishment, and it is generally with him the engineer has to consult in regard to the feasibility of his design or overcoming difficulties developed in the making of the casting. The facts of the matter are that it is in co-operation by the individuals concerned in the actual production of a casting, a machine or what-not, that the best results are obtained. The scientific, theoretical training of the engineer is good and proper, and in certain branches of engineering absolutely necessary; but in most cases, I think, the engineer will greatly profit by learning the observations of men who have spent long years in the shops and the foundries and by learning as far as may be the life history, if I may be permitted to use this expression, of the metals and the materials with which he is dealing; and if these notes on malleable cast iron have helped to emphasise this fact, this paper has not been read in vain.

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Messrs. Farnie & McCulloch have commenced business as engineers at 34, Ann Street, Glasgow.

The Brown Hoisting Machinery Company, of Cleveland, Ohio, U.S.A., has discontinued its London offices.

Messrs. T. Duncan and G. T. Wood, who traded as the Abbey Iron Company, 18, Southwark Bridge Road, London, S.E., have paid a first dividend of 1s. in the £.

Messrs. Penman & Company, of Glasgow, have recently delivered four extra large Lancashire steam boilers, each 32 ft. long by 8 ft. 3 in. diameter, for shipment to South America.

Considerable interest has been aroused by a rumour that has gained currency during the month to the effect that the extensive works of the Bolton Iron and Steel Company will shortly be shut down.

Mr. C. R. Adamson, 2, St. Augustine's Parade, Bristol, has been appointed by John Wright and Eagle Range, Limited, of Essex Works, Birmingham, to be their managing representative for the Midlands, South Wales, and the South-West of England.

THE ELECTRIC CRANE IN THE FOUNDRY.*

By Harry Sawyer, Muskegon, Mich.

It is not the purpose of this paper to enter into a technical discussion of the electric crane, but such a presentation of the subject as will lead to a better understanding between makers and users cannot fail to be mutually profitable.

The use of the electric crane in the foundry doing heavy work has become so general that even a reference to the older methods, by way of comparison, seems uncalled for.

There have been some interesting phases in the development and introduction of the electric crane. The scepticism of those in need of such machines, and the opposition of those engaged in the manufacture of the earlier types, was to be expected; but it is only fair to say that the users of cranes were quicker to recognise the advantages of the new type and to adopt it, than were the makers of the old.

The use of the electric motor and the sliding contacts, solved in so satisfactory a way the problem of transmitting power to a moving machine, that the travelling crane rapidly superseded the swinging crane in nearly all classes of foundry work where a crane is required. In one notable instance—pipe foundry work—the swinging crane was retained. Whether this was due to some peculiarity of the work that made the circular pit and the circular movement essentially better than the rectangular pit and corresponding crane movements, or whether it was due to the natural persistency of established practices, seemed for a time to be an open question; but the recent equipment of several pipe foundries with travelling cranes indicates that the latter was the correct explanation.

It is no doubt true that the foundry has set the standard of excellence for electric cranes. Some shops and mills may have heavier loads to handle and require greater speed, but the crane manufacturer recognises that the perfect control required in the foundry represents a higher state of development than mere requirements of capacity and speed. It should not be understood that good control is not required in mills and shops, particularly the latter, but as a rule the requirements of the foundry are much more exacting.

The conditions under which a foundry crane is operated are less favourable to continued good service than the conditions in a machine shop. It is more subject to overload, and the dirt and dust necessitate more careful attention; furthermore, the men directly responsible are usually less familiar with machinery, with the result that the crane too often does not have the care that it should. It is a mistake to assume that a crane which does the work of an army of labourers can safely be handled and cared for by one of that class. The importance of employing only thoroughly competent and conscientious operators and keeping the cranes in perfect repair cannot be too strongly urged. Prompt attention will reduce the total cost of repairs, and the extra cost of careful and competent men will be saved many times in the more constant service and longer life of the crane.

There is at the present time something of a demand for excessively high speeds, and the motives of the manufacturers who advise against them are sometimes misunderstood. It is not that the problem presents any difficulties from the manufacturer's standpoint. He may prefer to furnish a standard article, from considerations of cost and delivery, but oftener he is considering the direct benefit to the customer and the indirect benefit to himself. The manufacturer and user may recognise the same advantages and disadvantages but from their different standpoint; they do not see them in the same proportion.

The one advantage sought in high speeds is a saving of time, but this is often over-estimated. Take for example a 10-ton crane with full load speed of 20 ft. per minute. We may assume that the average load will not be more than one or two tons, that the average speed for such load will be 30 ft. per minute, and that the average lift is 5 ft. Allowing 50 per cent. more time for acceleration from a state of rest, and we find the time for an average lift to be 15 seconds.

If the speed of hoist were doubled, it would at first appear that one-half of this time, or 7½ seconds, would be saved. If 20 lifts were made per hour, the result would be a saving of only about 4 per cent. of the time. When it is remembered that many of the lifts must be very slow, regardless of what the crane is capable of doing, and that traverse movements are usually started as soon as the load is clear of surrounding objects and before the hoist movement is stopped, the actual saving is reduced to a very inconsiderable amount of time.

Where a large floor area is covered, a

* Paper read before the American Foundrymen's Association.

greater saving can be made by increasing speeds of horizontal movements, but the swaying of load which results from high speeds and sudden starting and stopping sets a limit to the saving that can be made in this direction.

Two objections may be offered to excessively high speeds. First, the accidents that are likely to result from putting a high-speed crane in the hands of an incompetent operator often cause the loss of much more time than is saved by the higher speeds, and greatly increase the cost of repairs. Second, if the crane is not usually run at full speed, there is a constant loss of power in the rheostat, and unnecessary wear and tear on the controller parts, both of which cause expense and loss of time. The above comparisons apply with the most force to cranes in foundries, and with least force to cranes in mills where much higher speeds are necessary and practical.

Next to the requirement of necessary strength in all parts for absolute safety, the most important point to be considered is perfect control of the hoisting mechanism. This depends upon three parts: the motor brake, the load brake, and the controller.

The motor brake is released by the current which operates the motor, and should require only as much current as is necessary to drive the machinery without load. It should be sufficiently powerful to bring the armature to a stop promptly, but without shock, when the current is interrupted.

The load brake is a far more important part. It must allow the machinery to run freely in hoisting but prevent the load from descending, except when the motor is run in the lowering direction. In most if not all forms of load brakes now in use the brake is applied by the action of the load. They may be divided into two classes: one in which the brake pressure is not reduced in lowering, but the motor acts with the load to cause the brake to slip; and the other in which torsion of the motor in the lowering direction reduces the pressure between the surfaces, allowing the brake to slip and the load to descend. The most common of the first class is the enlarged step bearing on a worm shaft. It can be used only in connection with worm gearing. It is a very simple, and may be made a very satisfactory, working brake. The most serious objection to it is this: If proportioned to give a fair margin of safety with the best conditions of lubrication, it will take considerable power to lower with moderate or poor lubrication, for the motor must overcome any excess of holding power over that necessary to sustain the load. This extra work in lowering means loss of time and power, and greater wear of parts.

Of the second class, there are two types: the coil type and the disc type. Both have their advantages and disadvantages. The disc type is more substantial in construction, gives better distribution of pressure over the friction surfaces, and consequently a much lower unit pressure; and as the pressure is strictly in proportion to the load, it gives higher speeds in lowering light loads. It has this disadvantage, that it is more sensitive to irregularities in lubrication.

In the coil brake the pressure and wear are concentrated principally at one end. While the brake is applied by the action of the load, the pressure and resistance to slipping are not strictly in proportion to the load. The torsional effort of the motor to release the brake is dependent upon the proportions of the brake parts, and not upon the load, hence the speed in lowering is approximately the same for all loads.

Both types are used by reputable builders, and both may be designed to give good results.

A good controller is indispensable to a satisfactory crane. The essential parts of the controller are the resistances and the means for varying the amount of resistance in the circuit, according to the speed and power required. The most common practice is to divide the resistance into sections, connect the sections together in series, and connect each section to one of a series of corresponding contacts. A brush is arranged to pass over those contacts, cutting more or less of the resistance into or out of the circuit. Various materials may be employed and details used to obtain the desired result, but certain conditions must be complied with if satisfactory results are to be secured.

The total resistance may be sufficient to allow the passage of only enough current to start the motor at a very slow speed with its smallest load. The number of sections must be sufficiently great and the resistance of these sections sufficiently small that no sudden or abrupt changes of speed will occur from the time the first contact is closed, sending the current through the resistance, to the time that all the resistance is cut out and the motor is given full current.

Durability of the controller and convenience in making repairs, are important considerations. The construction should be such that neither the resistance

material or the supporting insulation will be injured by the heat. Conservative rating and good ventilation are required to keep the temperature down to a safe point. Sparking and burning of contacts cannot be entirely prevented, but proper proportion of resistance to avoid great changes in voltage between consecutive steps and a well-designed magnetic blow-out will prevent serious burning. The brushes and contact pieces must be renewed occasionally, and they should be very accessible. It is important also that the resistance material should be removable without moving the controllers from their positions in the operator's cage. Economy of space, so far as it is consistent with proper sizes of parts, good ventilation, good insulation and accessibility is of importance.

Crane motors are usually series-wound. It seems almost unnecessary to say that they should be very simple and strong mechanically, that the electrical insulation should be of the best quality and that they should be designed to stand great variations in speed and load and sudden reversals under load without injurious effects. The highest possible efficiency at some one speed and load is not so important as a good average efficiency over a wide range. Motors of low or moderate speeds are preferable on account of the reduced gear ratio required between motor and winding drums or driving wheels.

Referring in a more general way to the design of cranes and the problems and limitations met by the designer, it is the exception rather than the rule that he has free hands to do as he might wish. Limited space; close approach of hook to roof, sides, and ends of building; perfect accessibility of all parts; a large factor of safety; low price—these are some of the requirements which, desirable as they may be, are not always compatible.

Manufacturers and users have underestimated the advantages to both of getting together. The manufacturer should understand fully the requirements of the user, and the user should know the full effect of the limitations he places upon the manufacturer.

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THE MUNICIPAL FOUNDRY AND ENGINEERING COMPANY, LIMITED, the United Engineering Company, Limited, the U.T.C. Brassfoundry Company, Limited, and the Waverley Engineering Syndicate, Limited, are in course of being wound up.

MAKING BEDS.*

YOUR committee in undertaking this work, was fully aware of the difficulties to be met with in having moulders who are accustomed to their own ways follow any rule, or set of rules, laid down for them. For that reason we gave the table prepared by Mr. West to an apprentice, who had been working at the trade about a year, and instructed him to follow the directions to the letter.

It must be said that this apprentice turned out exceptionally good work as the result, for his plates when cast far surpassed those made by moulders of mature years and experience. As the apprentice progressed with the work he became more and more interested, and a decided improvement manifested itself in casting after casting, as it was made. The metal was poured in various ways, and but two plates were scarred, and then only ½ in. deep.

For plates with wide and deep prickers, we took the additional precaution of driving down cast-iron rods between the rows of prickers and thoroughly venting them with a 3-16-in. vent wire. After building the runners and cleaning out the loose sand from the surface of the plate, we took a dust bag and shook on a fair coating of Portland cement, which has a tendency to form better surfaces than plumbago or lime. As the cement, after standing a few minutes, absorbs moisture from the sand and sets, it leaves a very tough and rigid surface, without being hard. This reduces the possibility of cutting in front of the runners, and holds the edges around the prickers in a very firm manner.

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A MOVEMENT for the organisation of the manufacturing industries of Great Britain has been started. The provisional committee which has been formed includes Colonel Sir John E. Bingham, Sir Joseph Lawrence, Mr. G. Byng (General Electric Company), Mr. R. K. Morcom (Messrs. Bellis & Morcom), Mr. Huko Hirst (Robertson Lamp Company), and Mr. W. C. Mountain (Messrs. Ernest Scott & Mountain). The chief objects are to represent to the Government and the country the principles, aims, and needs of manufacturers, and to bring about closer relations between employers and employés.

* Report of Committee of the American Foundrymen's Association.

THE JOHNSON SYSTEM OF CAR WHEEL MANUFACTURE.*

THE moulding and casting systems of the wheel plants of the Pennsylvania Railroad, and the Central Car Wheel Company, represent important improvements in the method of car wheel manufacture, but in both these plants the moulder continues the all important factor.

In the operation of the moulding machines at the American Car and Foundry Company's plant, Terre Haute, U.S.A., no skilled labour is required. The lifting in all operations is done by air hoists, and flasks and castings are all transferred on trucks and trolleys. The heaviest work now being done is rapping the sand from the castings, and a special device is being designed to remove the sand from the wheel. No single operation in moulding requires more than a half minute, which indicates the possibilities of the plant, and while an output of 30 and 35 wheels per hour has already been reached, there is a possibility of producing 50 or 60, the sand-handling equipment having a rated capacity of 60 complete moulds per hour.

The Johnston system employs two moulding machines: one for producing the cope side of the mould and the other the drag. There is also the sand-handling equipment, which tempers, cools, screens, and conveys the sand from the shake out to the storage bins and feeders above the machines, and a rectangular track system on which are operated the trucks that carry the flasks to and from the moulding machines. The Terre Haute foundry, in which this system is installed, is 292 ft. long and 80 ft. wide, and the entire equipment occupies a rectangular space 45 by 203 ft. At the lower end of the foundry are located the 59 annealing pits, with a capacity of 18 wheels each, and they occupy a space approximately 80 by 85 ft.

FIG. 1.—COPE AND DRAG MOULDING MACHINES AND SAND FEEDERS.
THE JOHNSON WHEEL-MOULDING SYSTEM AT THE AMERICAN CAR AND FOUNDRY COMPANY'S PLANT, TERRE HAUTE, U.S.A.

The moulding machines, Fig. 1, located at the upper end of the foundry, are indicated by 1 and 2 in Fig. 5. The drag mould is made on 1, and the cope on 2, and these are shown in Figs. 2 and 3 respectively. The general construction of the machines is that of a press having cast iron bases, with top compression members made of steel beams, the two parts of each machine being held together by heavy steel bolts or columns. On the base of each rests a cylinder which supplies the pressures, and the circular table

* From the "Iron Age."

rotates from the centre, which is one of the supporting columns of each press. The tables have four openings at A^1, B^1, C^1, and D^1, Fig. 5, which in rotation centre over the cylinders which supply the pressure. The tables are supported by castings resting on the base of the press, which are fitted with roller bearings on which the tables rotate. Each of the tables has four patterns, the latter having bosses on their under side, the diameter of which is the same as of the openings in the tables. The boss height is equal to the table thickness. The boss serves two purposes; it is a guide in centring the pattern on the table, and it shortens the travel of the piston a distance equal to its height. Directly over each cylinder supported by a swivel or loose pin against the beams, are packings or pressure plates. The contour of the plates is practically the same as that of the patterns of the castings to be made. The plates are recessed to prevent contact with the bars in the flasks, and the swivel supports make them readily adjustable with reference to the bars.

The operations in making a mould on the drag machine at 1, Fig. 5, are as follows:—Four duplicate patterns are placed on the table, designated as A^1, B^1, C^1, and D^1. A flask is placed over the pattern at A^1, using an air hoist on trolley 10 for that purpose. A quarter turn is given the table, and another flask is placed over the pattern at A^1, and at the same time the flask now at B^1 is filled with sand from the hopper immediately above. A sweep attached to the hopper distributes the sand in the flasks and leaves the contour similar to that of the pattern. Another quarter turn of the table and the operation at A^1 and B^1 is repeated, and at C^1 the mould is being pressed. For the pressing operation, a plate on the end of the piston contacts with the boss on the pattern, lifting the pattern, flask, and sand up against the pressure plate and continuing the travel until the mould is formed. The pressure being released, the pattern with the mould is lowered to the table.

As shown in Fig. 6, the pressure is supplied by two cylinders in combination, and designed with reference to the economical use of compressed air. In

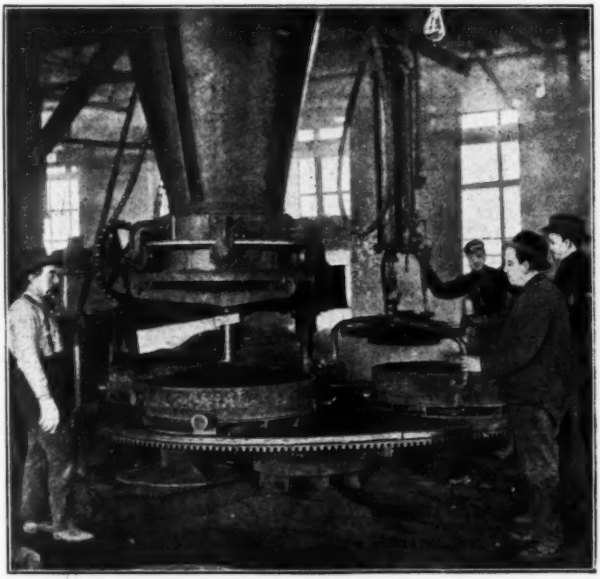

FIG. 2.—DRAG MOULDING MACHINE.

THE JOHNSON WHEEL-MOULDING SYSTEM AT THE AMERICAN CAR AND FOUNDRY COMPANY'S PLANT, TERRE HAUTE, U.S.A.

lifting the pattern, flask, and sand up to the pressure plate, and in compressing the loose sand, only sufficient power is needed to lift the dead weight. The travel in addition to that necessary to compress the loose sand compensates for the irregularity of the contour of the flask and pressure plate. When the table

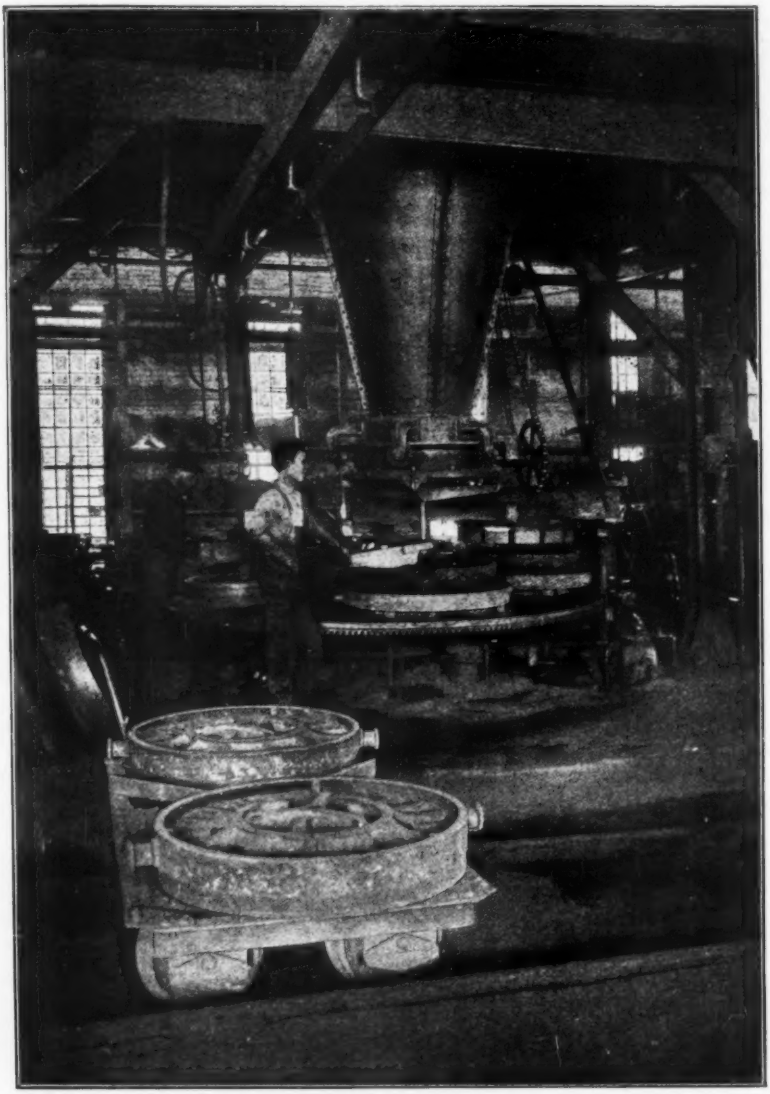

FIG. 3.—THE COPE MOULDING MACHINE.
THE JOHNSON WHEEL-MOULDING SYSTEM AT THE AMERICAN CAR AND FOUNDRY COMPANY'S PLANT.

is given the quarter turn there must be sufficient clearance to permit the highest

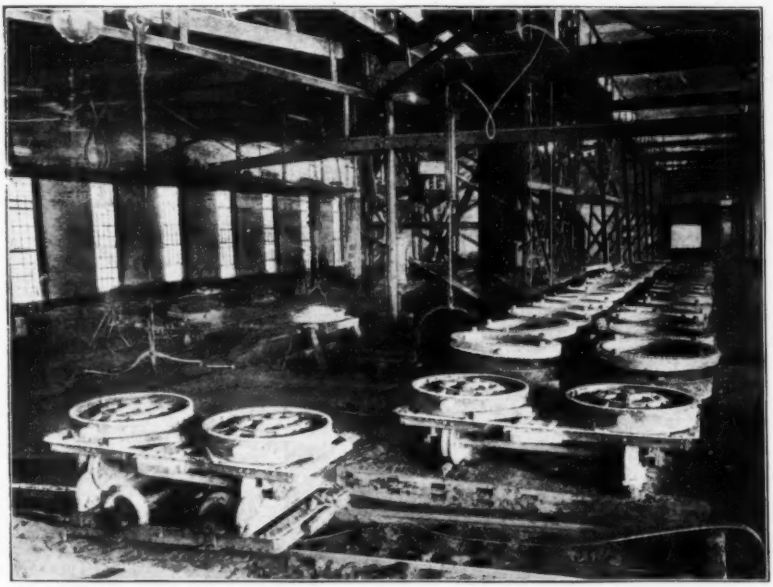

FIG. 4.—VIEW SHOWING SHAKE-OUT TRANSFER CAR, FLASKS ON TRUCK RETURNING TO MOULDING MACHINE, AND SAND-HANDLING EQUIPMENT.

point of sand to pass under the lowest point of the pressure plate.

The piston of the larger cylinder contains the smaller cylinder. In operation the movement of the lever B through the cock C, forcing the oil into the cylinder E, Fig. 19, through the check valve F and forcing up the piston G, which carries the load to the pressure plate of the machine. At the end of this upward

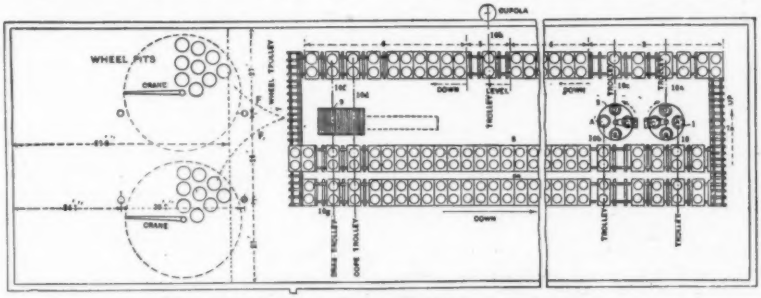

FIG. 5.—GENERAL PLAN OF WHEEL FOUNDRY.

THE JOHNSON WHEEL-MOULDING SYSTEM AT THE AMERICAN CAR AND FOUNDRY COMPANY'S PLANT.

the tank A, Fig. 6, contains a sufficient quantity of oil at least to fill the smaller cylinder. Air is admitted to tank A by stroke a projecting arm opens the valve H, admitting air into the large cylinder I, Fig. 7, and the upward movement of

piston J completes the mould. Returning the lever B to its original position the air is exhausted, the oil returns to the tank, and the pistons to their original positions. Oil is used to fill the cylinder E in preference to air, on account of the high pressure on the contents of this cylinder when air has been admitted to the cylinder I. The air is admitted to the large cylinder through a pressure regulating valve, and each mould receives the same number of pounds pressure. The travel of the larger piston is but one-ninth of the entire upward movement.

A third quarter turn is given the table, and while the operations at A^1, B^1, C^1 are repeated, the pattern and flask at D^1 are clamped together and lifted off the table by an air hoist on the trolley 10*a*, Fig. 5, and after being turned over are placed on a truck on the track 3. The clamp is then loosened and the pattern lifted off and returned to the table. It will be noted that the operations at A^1, B^1, C^1, and D^1, are carried on simultaneously.

The same movements are gone through in making the cope side of the mould indicated by 2, Fig. 5, except that at D^1 the mould is lifted off, leaving the pattern on the table. The reason of this difference is that the shape of the drag mould and the distribution of the sand are such that it is not practical to lift the mould off the pattern. The drag mould having been placed on a truck, the truck is

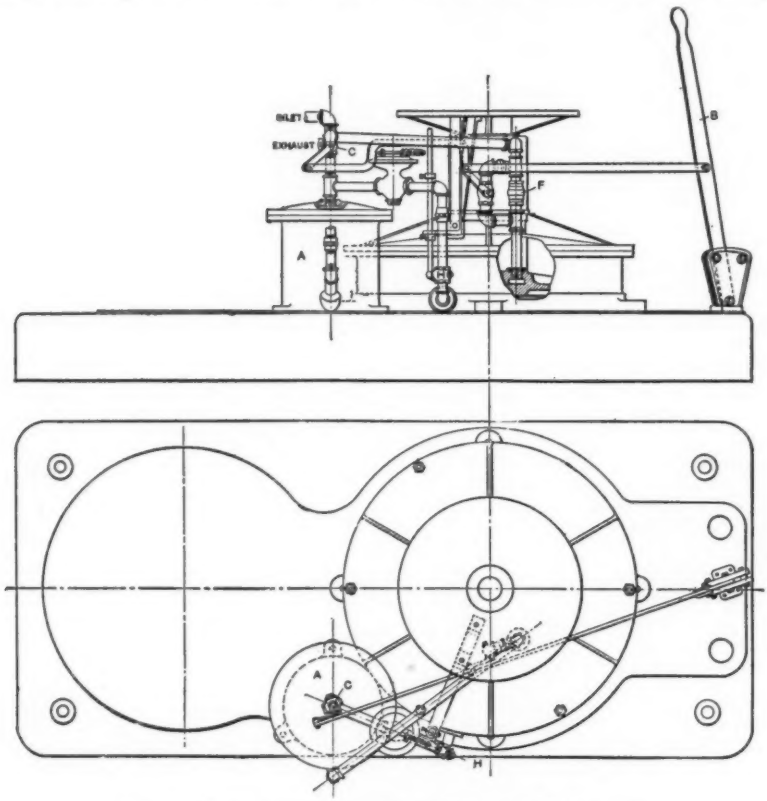

FIG. 6.—PLAN AND ELEVATION OF PRESSURE CYLINDERS.
JOHNSON WHEEL-MOULDING SYSTEM AT THE AMERICAN CAR AND FOUNDRY COMPANY'S PLANT.

moved forward and the cores set in the mould. Another movement of the truck brings it opposite the cope machine, when the placing of the cope in position completes the mould. The bowl into which the metal is poured is made separately and set in place after the mould has been closed.

The finished moulds are now moved along on the trucks on the storage track, and as soon as 52 of the moulds are set up on 26 trucks the blast is put on and the pouring begins. The cupola is situated at about the centre of one side of the foundry, and the iron is tapped into a 5-ton ladle, which ensures uniform temperature for all the wheels poured with this iron. From the ladle the iron is tapped into a bottom pour ladle, which holds sufficient for one wheel and an additional 50 lbs. for a runner. These bottom pour ladles are raised into position by means of an air hoist on a jib crane. As soon as two moulds on one truck have been filled another truck containing two moulds is brought up, and the same operation continues. The section of track 5, Fig. 5, is level, this being directly in front of the cupola, and it is desirable that the moulds be level when receiving the metal. Section 4 of this track is used for the storage of the finished moulds, and it is desirable to have room on this section to store a sufficient number of moulds to allow for any temporary delay at the machine, and if an emergency arises to take care of the metal already in the cupola.

After the wheel has been poured, a sufficient time is allowed for cooling before it reaches trolley 10*d*, at which point the cope is lifted off and taken to the grate 9, where the sand is shaken out and falls into the sand pit beneath. This cope flask is then deposited on the truck on the track 8, on which the drag flask is already in place. Placing the cope flask on top of the drag flask is desirable, as in moving the trucks forward to the moulding machines the cope machine is reached first and the cope flask lifted off, after which the truck is moved forward and the drag flask can be lifted off. When the truck reaches the trolley 10*f* the casting is taken to the grate 9, where the sand is rapped off. From the grate it is taken to the pits on trolleys F. These trolleys run on counter-balanced hinged tracks. The weight of the casting lowers the tracks and the casting is carried down grade to the pits. Relieved of the weight the track rises and the trolley returns to its original position.

The flask truck with the drag still on it is placed on the transfer truck on the track 7 and transferred to the track 8, tied at trolley 10*g* the drag is taken to the grate 9, the sand removed, and the drag returned to the truck. In order that the flask, or more particularly the chiller, may have sufficient time to cool before using a second time, it is necessary to have the second track 8*a*.

The construction of the flask in which the drag part of the mould is made, and which is practically the same as that of

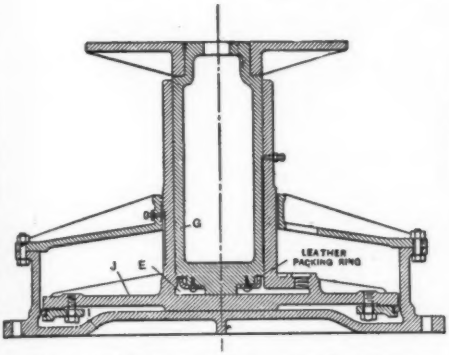

FIG. 7.—DETAILS OF PRESSURE CYLINDER.

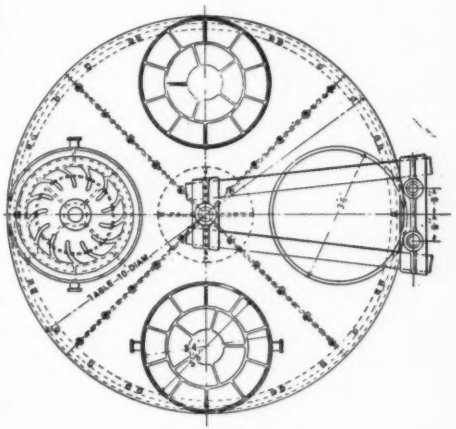

FIG. 8.—PLAN OF MOULDING TABLE.

JOHNSON WHEEL-MOULDING SYSTEM AT THE AMERICAN CAR AND FOUNDRY COMPANY'S PLANT.

the cope flask, is both interesting and novel. It is customary in making the drag side of a car wheel mould to use a ring and bottom plate. The general impression exists that it is dangerous to pour a mould without having the sand supported by a plate or in some way other than by the bars in the flask, and more particularly since it is common practice to pour the metal into a car wheel mould rapidly and at a high temperature. Considering the pressure per square inch applied in making the mould as compared with the weight of the metal of the mould per square inch, it can readily be seen that there is very little more strain on the drag than on the cope side of the mould. In producing several thousands of moulds with the machine in a specially designed flask with bars it has been demonstrated to be entirely satisfactory and safe. The feature of the drag flask makes it possible to make the mould by pressing the sand against the pattern. It has been attempted to make the mould by pressing the pattern into the sand, using a pattern with adjustable parts. Such patterns, however, have proved unsatisfactory on account of the rapid wear due to the sand getting in the joints.

The trucks used for conveying the moulds to the cupola and shaking out point and for returning the flasks to the machine are constructed of steel shapes with cast-iron wheels. Spring buffers are attached to each truck, so that when they come in contact the shock does not destroy the mould. Each truck carries two moulds. The tracks on which they run are standard gauge and are designated as

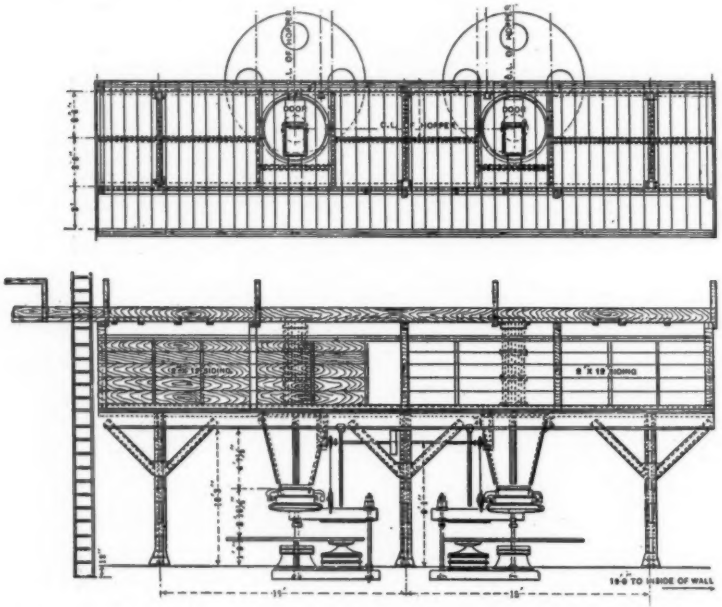

FIG. 9.—PLAN AND ELEVATION OF SAND STORAGE PLATFORM AND FEEDERS. JOHNSON WHEEL-MOULDING SYSTEM AT THE AMERICAN CAR AND FOUNDRY COMPANY'S PLANT.

3, 4, 5 and 6, on one side and 8 and 8*a* on the other, Fig. 5. The steel rails are laid on ordinary cross ties with a very slight decline in the direction of travel of the loaded trucks. This decline with tracks and roller bearings for the journals makes it a simple matter to move the trucks. For instance, on the cooling track 8 when a truck is moved forward at the machine all the trucks on the tracks follow.

Tracks 7 and 7*a* are oppositely inclined. The gauge is 3 ft. and a specially designed truck on each is used in transferring the

flask trucks. The incline of these short tracks is equal to the incline of the longer tracks. While the trucks run on an inclined track, the construction of the car is such that the rails on the top are level with the rails of the standard gauge tracks, whether at the bottom or top of the incline. The motive power is applied by friction pulleys to a shaft on which is a drum. The car is hauled by grade by the winding around the drum of a cable, one end of which is attached to the track. The return is by gravity.

The sand-handling equipment, shown in Fig. 9, is one of the important features of the system and occupies the greater portion of the space inside the rectangular tracks. The sand is received at the shake out, where it passes through double deck hoppers, is tempered, cooled and screened and delivered by reciprocating conveyors to the storage bins, Fig. 9, located above the moulding machine.

The sand when shaken out passes through a grating into a double deck hopper, the bottom of whose top section consists of a pair of hinged doors, arranged for dumping the sand from one or two flasks, in the bottom of the hopper. The operation of the doors controls the valve of the water reservoir, allowing a measured quantity of water for tempering to be sprayed on to the sand.

The sand is then fed from the bottom of the hopper to the elevator boot by a reciprocating conveyor. This conveyor is built of steel and has a removable steel hood providing an enclosed space through which the air is drawn for the purpose of cooling the sand. The elevator lifts the sand and discharges it through a chute into a hexagonal revolving screen on the overhead platform. The elevator is of the belt type with steel buckets. The buckets are of large area to afford the largest surface of sand possible to the action of the air draft. The sand is cooled by an exhaust fan, the air being drawn down through the elevator leg, then through the reciprocating feeder conveyor and exhausted outside the foundry building. This fan also draws off the steam rising from the hot sand when sprayed with water, and exhausts it outside the building through the elevator leg and the reciprocating feeder conveyor.

The discharge from the reciprocating conveyor to the storage bins is controlled by a series of five gates in the bottom of the conveyor trough over the bins. These gates can be adjusted to distribute the sands equally in the bins, or, by closing part of them, can be discharged at any point desired. There are no screens in the bins; the latter are merely provided for storage to supply the feeders and are designed to be practically self-cleaning, as all the sand can be drawn out through the feeders if desired. The two feeders, Fig. 9, one over each moulding machine, are conical in shape, and of steel construction. They are closed at the bottom by revolving gates and screens and are so arranged that when in operation a fine volume of sand is fed to the patterns, and when the operation is stopped the sand ceases to flow immediately. The operation of these feeders is controlled by means of a lever which engages a friction clutch. When sand is desired the lever is thrown over and the hopper set in motion, and by reversing the lever the friction clutch is disengaged and the revolving gate immediately ceases operation.

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SOME USES OF PURE MANGANESE AND ITS ALLOYS.

A good deal of information has recently been published regarding the uses of magnesium as a deoxidiser for obtaining sound castings of certain metals and alloys. It does not, however, appear to be generally known that manganese can be used with even better and more far-reaching results for most purposes, and therefore the following brief remarks may be of interest.

As with magnesium, so also with manganese, it is necessary to use the purest metal obtainable. Manganese made by the Goldschmidt alumino-thermic process has a purity of about 99 per cent., the balance being chiefly silicon; this manganese is free from carbon and technically free from iron, a point which makes it of great benefit for special brass and other alloys.

Pure manganese is a very brittle metal, and resists atmospheric influences for an unlimited time; its fusing point is about 2,240 degrees Fahr. Among its chief characteristics is the ease with which it alloys with copper, nickel, zinc, tin, aluminium, and other metals.

Pure manganese may be added in any percentage to zinc copper alloys, the result being a very considerable increase of strength and density, and often also of elasticity; such alloys can also be more easily rolled. It should not, however, be added to tin, copper alloys containing more than about 2 per cent. to 3 per cent. of tin as the quality of the material is thereby deteriorated, but if the con-

tent of tin is kept low, manganese may be added with advantage.

For nickel castings, manganese is used as a deoxidiser to produce a greater density. In this case about 2 per cent. is added to the molten nickel. This is more advantageous than an addition of magnesium, for this latter, if added in excess, has a bad effect, whereas there is no such danger with manganese.

In the manufacture of nickel coins in mints, manganese is added to the nickel copper alloys to the extent of about 2 per cent. It is also used with beneficial results for making German silver. If about $\frac{1}{2}$ per cent. is added, a bright colour is produced similar to that of silver.

For aluminium alloys an addition of manganese copper, free from iron, which is made from pure metallic manganese and electrolytic copper, is preferable to zinc or nickel additions. About 3 per cent. of manganese-copper will increase the strength of the material, give denser castings, and the alloy can be more easily machined—moreover, the cost is lower than an addition of nickel.

Copper and bronze castings lose their brittleness if manganese is added instead of phosphorus; a material is thus obtained in which threads may be easily cut. Manganese-copper alloys are made to a large extent, containing from 2 to 12 per cent. of manganese. Bronzes with 5 to 6 per cent. of manganese have about the same colour as copper, and are very fire-resisting; they are, therefore, used especially in the fire-boxes of locomotives. Sometimes about $\frac{1}{2}$ per cent. of nickel is added to such a copper-manganese alloy. For the preparation of manganese-copper alloys it is always preferable to first melt alloys with a high content of manganese—for instance, 70 per cent. of copper and 30 per cent. of manganese. If ferro-manganese is used, even of the best quality (about 80 per cent. manganese, 8 to 9 per cent. iron) the iron is always introduced into the copper, reducing the elasticity of the alloy and its fire-resisting qualities. Pure manganese alloys with copper with very small loss, which is an advantage over ferro-manganese, and its higher price is counterbalanced by the uniformity and improved quality of the castings.

Manganese fulfils two purposes. First, it is a deoxidising agent. In general, an addition of about $\frac{1}{4}$ per cent. of manganese is sufficient. Compared with other deoxidising agents, like phosphorus, manganese has the great advantage that if a surplus quantity is added it improves the quality of the bath (the only exception being the case of bronze rich in tin), whereas, if too much phosphorus is added, it impairs the quality of the bath. In some cases, about 1 per cent. of manganese is added, in conjunction with phosphorus.

Secondly, it improves the quality of a great many metallic alloys. It combines easily with, and has a great affinity for, oxygen; moreover, since manganous oxide slags are very fluid and have a low specific gravity, they easily and quickly separate out of the baths. All castings with manganese alloys are to be made under exclusion of air as far as possible. It is, therefore, useful to sprinkle a small quantity of borax upon the surface of the metallic bath in the crucible. It then forms a thick plastic slag.

High percentage manganese-copper alloys are made by first melting the copper in a graphite crucible and then adding manganese pieces the size of a hazel nut, gradually, by portions of 10 to 20 lbs., and the bath is thoroughly stirred. Before adding the manganese, the copper slag has to be removed. The metal must be repeatedly stirred, and after 5 to 10 minutes' interval, the next portions of manganese are added until the whole charge is complete. If the bath contains an alloy of only 20 per cent. of manganese it must be heated for an hour; in the case of an alloy of 30 to 50 per cent., heating for an hour and a half is necessary. It takes altogether two to three hours to complete a crucible charge of 20 to 30 per cent. manganese-copper.

High percentage manganese-alloy is best cast in the form of thin flat rods, which can then be cut into narrower strips. In this form they are more easily used for the preparation of other alloys. It is still better, however, to pour the original alloy into water, so that it assumes a granulated form. The small pieces thus formed facilitate the preparation of new alloys.

For a 100-lb. charge of 30 per cent. manganese-copper, 73 lbs. of copper and 32 lbs. manganese are required. The loss is, therefore, small. The waste of the preceding charge is placed on the crucible containing the fluid copper. Before adding the manganese the resulting highly-fluid slag must be removed.

Manganese alloys with tin and zinc can also easily be prepared; generally, the following proportions are used :—20 parts of manganese to 80 of zinc, free from lead; 50 parts of manganese to 50 parts of tin, free from lead. The slag formed

on the molten tin and zinc must, of course, be removed before adding the manganese, and the charge is kept heated for a couple of hours. With zinc it is important to take care that the temperature remains constant and does not increase. The loss in the preparation of 20 per cent. manganese-zinc is only 4 per cent.

Manganese-copper, free from iron, is used in the nickel cupro manufacture of cartridge cases, etc., and does away with the annealing process.

The above will be sufficient to show the large field of usefulness for this metal and its value to the metal founder. Messrs. Thermit, Limited, of 27, Martins' Lane, E.C., report, in fact, a very greatly increasing demand which speaks well for its popularity.

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THE SEARCHING POWER OF METALS.

THE difference in the searching power of some metals has exercised the minds of most men interested in the casting of them and their alloys.

In an article on "Cores" in your April number, lead, brass and iron were particularly mentioned by the writer, who said that the difference could not be accounted for, either by the temperature or specific gravity, and then asked the question, What is the cause?

Now, as it seems that he looks at the question from a moulder's point of view, and, I take it, that it is moulders to whom it is principally addressed, I will try to demonstrate, that they are the causes of the difference, by treating lead and iron, which show the maximum and minimum of specific gravity and fusible temperature of the above-named metals.

Suppose we make two castings, one each of lead and iron, using the same box for both, and with ordinary black sand, pouring the metals hot enough to ensure sharply run castings, and putting the same amount of work on each. The lead casting will be rougher than the iron one, although not quite so much as seems at a first glance, as the coarseness is more easily observed on the white surface.

Now, if the gates of the two moulds have been filled to the same level, there is a greater pressure on the sand of the lead mould, because of the specific gravity, and as the lead casting has to be poured much faster than the iron one, there is still greater pressure put upon it, which will account for some of the roughness seen on the face.

The fluid iron, when it is poured into the mould, generates gases at once from the coal-dust, moisture, and any vegetable matter which the sand facing the mould contains. The temperature of the iron generates these gases so quickly and in such volume, that as the metal forces them into the sand, and this is so tightly packed, that they cannot escape too freely, all space between the grains of sand are filled with them, at a pressure which keeps the metal from penetrating very far. The greater the volume of gas generated, whether caused by the addition of coal-dust or moisture to the sand, and the tighter the sand is packed, takes from the penetrating power of the iron.

To illustrate this point, we will take the case of a lump of wet sand on the face of an otherwise perfect mould, which most moulders have experienced. The whole of the casting is perfect except that portion where the wet sand has been, and will present a glazed hollow, denoting that the metal has been kept from touching the sand by the extra amount of steam generated, and which could not escape before the metal solidified. The temperature also tends to cause the difference in this way. The great heat of the molten iron dries the face sand of the mould very quickly, and forms it into a hard cake before the full pressure of metal is on it, and it is a well-known fact that the metals used in the foundry cannot pierce dried sand to the same extent as they do green sand.

In making a mould for a lead casting, a fine grained sand is used, or ordinary foundry sand with a thick coating of some refractory powder, which is shaken through a canvas bag. This mould can be rammed as tight as it is possible, as, unlike iron, there is very little gas generated before the metal is solid. If we were to ram a mould as tight for an iron casting, using a comparatively coarse face sand, and did not vent it well we would either find that some of the metal would be blown out, or if it did remain in the mould, the casting would be imperfectly run and have a very smooth skin, the gases having occupied some of the mould space.

All this goes to show that it is mainly the temperature acting through the gases, and drying the sand more quickly, which causes iron to be deficient in that searching quality which metals fused at a lower temperature possess.

ELECTRICAL PYROMETERS.

With the increase of refinements in manufacturing processes it is becoming more and more necessary to determine definite temperatures for the various manufacturing stages and to insure that during the entire range of processes the heat is kept up by the workmen or operatives at these predetermined temperatures. Thus a measuring instrument giving indications over a wide range, which is at once simple and accurate and permits of being handled and understood by any workman or attendant without special mechanical or electrical knowledge, has become an absolute necessity. Hitherto electrical pyrometers have been of the electrical resistance type, based upon the principle of measuring the resistance offered by a platinum wire (when heated) to an electric current, the resistance being in a definite ratio to the degree of heating. This type of instrument, although it has achieved a considerable popularity, has the drawback of necessitating the use of a separate battery, requiring constant attention, whilst a certain amount of delicate operation is required before the reading is obtained. This makes these instruments unsuitable for the hands of an ordinary workman. Moreover, owing to the cost of the metal (platinum) employed, and the complicated construction of the galvanometer and balancing gear, such instruments are expensive.

Messrs. Schäffer & Budenberg, Limited, of Whitworth Street, London Road, Manchester, have recently put upon the market an instrument which is entirely self-contained and self- or direct-indicating, requiring neither battery nor any special manipulation, the exact temperature being observed by simply glancing at the dial. The aim of the makers has been to produce a series of instruments suitable for the different conditions that occur in modern industrial practice or in scientific laboratories, combining simplicity of routine and manipulation with permanent accuracy. These pyrometers consist of a thermo element or insertion tube for exposing to the source of heat, and a sensitive galvanometer to indicate the temperature at

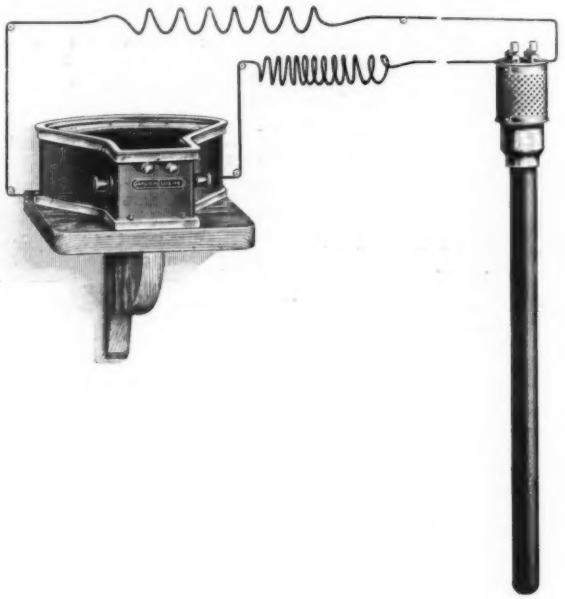

Fig. 1.—For Temperatures up to 2,300° Fahr. or 1,250° Cent. Messrs. Schaffer & Budenberg's Electrical Pyrometer.

any convenient distance from the source of heat. If desired, a number of thermo elements can be connected up to one galvanometer fixed up at some central station or office, and, by using a simple switchboard, the temperature of any of the different places can be observed at any moment. Moreover, the galvanometers can be fitted with maximum or minimum contacts to ring a bell at any predetermined temperature. A special recording galvanometer can also be fitted for recording minute variations of temperature during day or night.

the thermal difference between the cold and hot junctions, or with the intensity of the heat to which the thermo element is exposed. The relation of this current to the temperature has been determined accurately by experiment, and the scale of the galvanometer can therefore be divided to read directly in degrees Fahrenheit or Centigrade; thus, as soon as the thermo element is exposed to heat or cold, the electric pressure or current produced in the two rods actuates the mechanism of the galvanometer, and the needle of the latter indicates directly the

FIG. 2.—FOR FOUNDRY USE.
MESSRS. SCHAFFER & BUDENBERG'S ELECTRICAL PYROMETER.

The thermo element consists essentially of two wires or rods of different materials, which are joined or fused together at their extreme ends exposed to the heat (hot junction). The other extremes of the rods (called the cold junction), which project into the open air, are connected by means of screws to the leading wires of the galvanometer. The two rods of the thermo element are of different electrical conductivity. If, therefore, the ends of the rods at the hot junction are heated, a difference of potential is produced, causing an electric current to flow, varying in strength with the degree of exact temperature of the hot junction, or at the place where the thermo element is inserted.

The thermo elements are made in various lengths and fitted with protection tubes and flanges or screwed couplings to adapt them exactly to the different processes or apparatus for which they are required. The constituents of the thermo element vary according to the intensity of the heat for which they are intended. For temperatures up to 1,100 degrees Fahr. or 600 degrees Cent. the element consists of nickel and constantan (a special metal alloy). For temperatures

up to 2,300 degrees Fahr. or 1,250 degrees Cent. nickel and a special carbon are used, and for temperatures up to 2,900 degrees Fahr. or 1,600 degrees Cent. platinum and platinum-rhodium.

Fig. 1 shows the galvanometer or scale on which the temperature is indicated connected to the thermo element. For general boiler-house and superheater work a scale of 900 degrees Fahr. is quite sufficient, and the instrument can be attached in a vertical position to a wall, and so enable the graduation to be seen at a moderate distance. For higher temperatures the galvanometer is best placed in a horizontal position, as shown, at some little distance from the apparatus or heated metal whose temperature it is desired to register.

Fig. 2 shows the method of using the instrument in the foundry for ascertaining the temperature of molten metal. In this case the lower portion of the element is protected by crucible material or by a tube of pure graphite with an insertion of quartz glass. In the latter case the graphite protection can only be 8 in. long, whereas in the former case (for temperatures up to 2,370 degrees Fahr.) the protection tube can be any desired length, a feature of great convenience when the increase of temperature has to be watched while the crucible is in a furnace or oven, so that it can be lifted out at any moment.

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TRADE TALK.

Mr. E. C. Amos, consulting engineer, has removed to 22, Walbrook, London, E.C.

A petition has been presented for the winding up of the Atlas Steel Works, Limited.

Cutting Brothers, Limited, have established a branch at Park Works, Stamford.

Messrs John Taylor, Sons & Santo Crimp have moved to Caxton House, Westminster, S.W.

Mr. S. Walker, engineer and brassfounder, of Stockport, Cheshire, has been adjudged bankrupt.

Another large engineering firm—Messrs. S. Cutler & Sons—is about to leave the Metropolis.

Messrs. Hutchinson & Company intimate that their head office address is now 63, Albion Street, Leeds.

P. & W. McLellan, Limited, of Glasgow, have removed their London office to 108a, Cannon Street, E.C.

Ruston, Proctor & Company, Limited, have lately made an issue of 150,000 preference shares of £1 each.

Bruce Peebles & Company, Limited, have announced an issue at par of 8,951 ordinary shares of £5 each.

Macartney, McElroy & Company, Limited, have removed to Caxton House, Westminster, London, S.W.

The business of Messrs. George Thomas & Company has been removed to Parsonage Lane, Deansgate, Manchester.

The Empire Engineering Company have removed to the Empire Works, Clarendon Road, Salford, Manchester.

Mr. J. A. M'Gilvray, consulting engineer, has removed his business to 12, Dixon Street, St. Enoch Square, Glasgow.

The discharge from bankruptcy of Mr. B. Elton, iron founder, late of Edgbaston and Tipton, has been suspended for two years.

The London business of Sanderson Brothers & Newbould, Limited, has been removed to Caxton House, Westminster, S.W.

A fire broke out recently at the Kirkstall Forge, Leeds, of the Kirkstall Forge Company, Limited, doing considerable damage.

Mr. J. G. McLoughlin, of Newcastle-on-Tyne, has acquired the engineering business of Messrs. Snelling & Company, Grimsby.

Mr. H. C. Wolfe, 7 and 8, Great Winchester Street, E.C., has been appointed the London agent of Hulse & Company, Limited, Salford.

Messrs. M. S. Stevenson and C. H. Duff, trading under the style of the Birmingham Foundry Company, have dissolved partnership.

A destructive fire occurred recently at the St. Rollox Works, Glasgow, of the Caledonian Railway Company, doing damage estimated at £75,000.

Messrs. G. Cawwood and A. Cawwood, iron founders, Rotherham, Yorkshire, trading under the style of Geo. Cawwood & Son, have dissolved partnership.

The South Durham Steel and Iron Company, Limited, West Hartlepool, have announced the issue of 100,000 ordinary shares of £1 each at par.

Cammell Laird & Company, Limited, have made an issue through Messrs. C. J. Hambro & Son of £750,000 5 per cent. mortgage debenture stock at 103½ per cent.

The Panmure Shipyard, Dundee, has

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been vacated by the Dundee Shipbuilders' Company, Limited, and taken over by the company which has bought the business.

THE STAVELEY COAL AND IRON COMPANY, LIMITED, of Chesterfield, are carrying out extensions to their iron works and pipe foundry which are estimated to cost £250,000.

MESSRS. JOHN TURNBULL, JUNR., & SONS, of 190, West George Street, Glasgow, have removed to Port Dundas, where their Canal Basin Foundry Works are situated.

IT has been rumoured that the directors of Babcock & Wilcox, Limited, and of the Stirling Boiler Company, Limited, have formulated a scheme for a fusion of the companies.

MR. J. HALCROW, who holds the London agencies of the Hanover Locomotive Works, and of the Bochumer Verein, Augsburg and Nürnberg Engineering Works, has removed to 18, Coleman Street, E.C.

MESSRS. HODGSON & COWHAM, of 16, Grosvenor Buildings, Steelhouse Lane, Birmingham, have been appointed by the Middlesbrough Steel Strip and Hoop Company as their sole representatives in the Midland districts.

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PERSONAL.

THE value of the estate of the late Sir Charles Tennant, Bart., is £2,700,000.

SIR JAMES B. DALE, BART., has been elected a director of Pease & Partners, Limited.

THE value of the estate of the late Sir David Dale, Bart., has been returned as £121,831 gross.

MR. W. H. ELLIS, of John Brown & Company, Limited, has been elected a director of Davy Brothers, Limited.

THE late Mr. W. M'Onie, of the Harvey Engineering Company, Limited, of Glasgow, left estate valued at £19,322 gross.

MR. H. D. REES has been appointed manager of the Burry Works, Llanelly, of Richard Thomas & Company, Limited.

MR. A. B. MARKHAM, M.P., returned from the Mediterranean recently, but left again almost immediately for Aix-les-Bains.

MR. W. HODGSON, of Messrs. Hodgson & Stead, ironfounders, of Salford, has been made a Justice of the Peace for Salford.

MR. J. B. WOSTENHOLM, of Sheffield, has been appointed a director of the Kelham Rolling Mills Company, Limited, Sheffield.

THE late Mr. Charles Steer, managing director of Guest, Keen & Nettlefolds, Limited, left estate of the gross value of £77,483.

MR. W. F. OSBORN, of Messrs. Samuel Osborn & Company, Clyde Steel Works, Sheffield, has consented to fill the office of Master Cutler next year.

MR. S. J. ROBINSON, joint managing director of Wm. Jessop & Sons, Limited, Sheffield, has returned from a visit to the United States and Canada.

MR. A. NEWLANDS, of 1, Albyn Place, Edinburgh, is now the Inspector of Factories, in succession to Captain H. W. S. Kindersley, for the Edinburgh district.

LORD JOICEY has been elected president and trustee of the Northumberland and Durham Miners' Permanent Relief Fund, in the place of the late Sir David Dale, Bart.

MR. J. DONALD, of the firm of Donald & Taylor, shipowners, Glasgow, has been elected a director of the Cardiff Channel Dry Docks and Pontoon Company, Limited.

MR. J. MARSHALL, J.P., has been presented by the staff of the Britannia Iron Works, Gainsborough, with an illuminated address, upon the occasion of his seventieth birthday.

SIR ALFRED HICKMAN has been the recipient of a testimonial from the inhabitants of the Parliamentary Borough of Wolverhampton and district, in recognition of his Parliamentary services.

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DEATHS.

MR. WILLIAM BLACK, a director of Messrs. Moses Eadon & Sons, Sheffield.

MR. A. STRAUSS, of Messrs. A. Strauss & Company, metal merchants, Rood Lane, London, E.C.

SIR CHARLES TENNANT, BART., honorary president of the Steel Company of Scotland, Limited.

MR. H. WATSON, in his 70th year, at one time managing director of Clayton & Shuttleworth, Limited.

MR. W. WHYTE, consulting engineer, Newcastle, who founded the Combination Metallic Packing Company.

Ganister, Cupola Blocks, Fire Bricks,

Fire Clay.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

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REGISTERED TRADE GLYCO GLYCO GLYCO GLYCO MARK

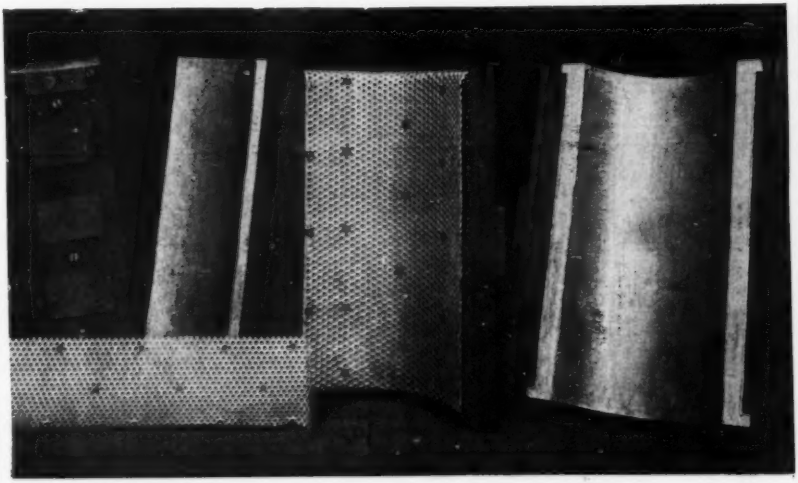
WE GUARANTEE "GLYCO" AS A BEARING LINER

EQUAL IN EFFICIENCY

TO THE HIGHEST PRICED TIN ALLOYS AT LESS THAN HALF THEIR COST.

PATENT GLYCO-EMBEDDED SKELETON BEARINGS.

The Illustration shows a Crank-Shaft Bearing, consisting of Steel Shell with Bronze Skeleton embedded in "Glyco."



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Mr. G. M. Marchant, head of the firm of G. M. Marchant, of the Rashcliffe Brass and Iron Works, Huddersfield, aged 59.

Mr. T. Preston, at the age of 82, who was at one time manager of Messrs. E. Green & Sons' Fuel Economiser Works, Wakefield.

Mr. R. H. Williamson, aged 49, managing director of the Union Iron Works Company, Limited, of Crowthorn, Ashton-under-Lyne.

Professor A. Ledebur, the eminent metallurgist, and a honorary member of the Iron and Steel Institute, in the sixty-ninth year of his age.

Mr. C. H. Crane, head of the Crane Ironfoundry Company, Limited, and a director of the Wellingborough Iron Company, in his 77th year.

Mr. W. H. Haley, senior partner of Messrs. E. & W. H. Haley, ironfounders, of the Lister Hills and New Foundries, Bradford, Yorks, in his 63rd year.

NEW COMPANIES.

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As supplied to the British . . Admiralty Dockyards.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.

We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blow-holes and other defects, than we formerly did.

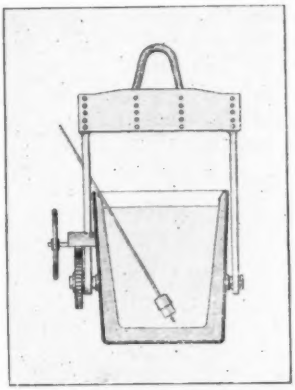
From MOUNTFORT PHILLIPS & Co., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, LTD. Cardiff.

PREVENTION OF BLOWHOLES IN CAST IRON.



A tin of our special compound fixed on a rod is held at bottom of ladle as shown; a strong re-action being thereby set up frees the iron from gases and impurities, which rise to the top.

RESULT: A denser casting of finer grain with increased strength.

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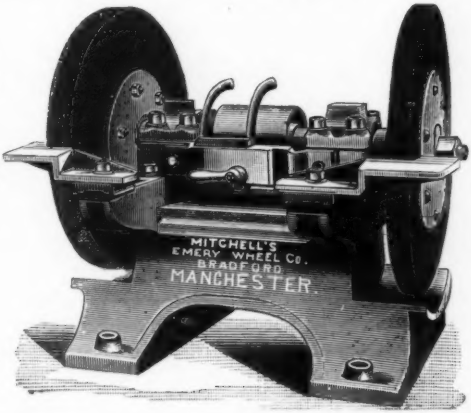

Emery or Corundum from 1 in. x $\frac{1}{8}$ in. to 50 in. x 12 in.

Enquiries solicited.

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Mill Street, Bradford, MANCHESTER.

Also at LONDON, GLASGOW, and BELFAST. LISTS FREE.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

Metals.	1905-6.	1904-5.
Iron—Scotch pig warrant ... ton	56 3*	—
—Middlesbro' warrants ... ... ton	50/0	45/6½
—W.C. M/nos Bessemer ... ... ton	67/6	57/0
—Stock, Scotch, June 30 ...tons	12,000	17,750
Copper—Chili bars, GMB ... ... ton	£82 0 0	£66 5/0
—Stock, Europe & afloat... ... tons	11,563	18,035
Tin—English ingots ton	£180 0/0	£141 0/0
—Straits ... ton	£177 5/0	£140 5/0
—Stock, Ldn. Hlnd and afit ... tons	—	—
Lead—English pig ton	£16 17/6	£13 5/0
Spelter—Ord. Silesian ... ... ton	£27 0/0	£24 0/0
Quicksilver—(75lb.) bottle	£7 5/0	£7 7/6
Antimony—Regulus ... ... ton	£115 0/0	£48 0/0

*Settlement price, sellers, cash.

Castings.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.		£ s. d.
Columns (plain)	6 12 6	to	7 2
Pipes, 1½ to 2½ in.	5 0 0	to	5 2 6
,, 3 to 4 in....	4 12 6	to	4 15 0
,, 5 to 8 in.	4 10 0	to	4 12 6
,, 10 to 16 in....	4 10 0	to	4 12 6
,, 18 to 24 in....	4 10 0	to	4 12 6
Chairs	3 15 0	to	3 17 6
Floor plates (open sand)	3 0 0	to	3 5 0

Scrap.

The quotations for scrap, subject to market fluctuations, are as follows: —Heavy wrought (mixed), £2 13s. 6d.; light wrought, £1 6s.; heavy cast, £2 6s.; all per ton f.o.b., London. Copper (clean), £75; brass (clean), £52 10s.; lead (usual draft), £15 10s.; tea lead, £13 15s.; zinc, £22 5s.; all per ton delivered merchant s yard.

SILICA FIRE BRICK Co.,

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GROUND GANISTER,

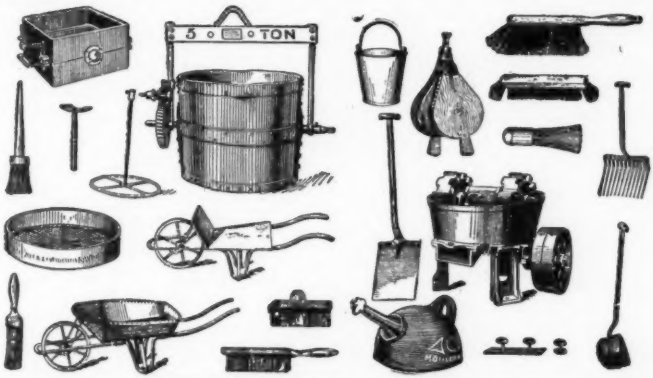
Wet or Dry.

Silco Cupola Bricks, 90 % Silica.

Better than Fire-clay Bricks for Cupolas.

Established 1863.

Jas. Durrans & Sons,



PHŒNIX WORKS, PENISTONE, Near Sheffield.

Manufacturers of all

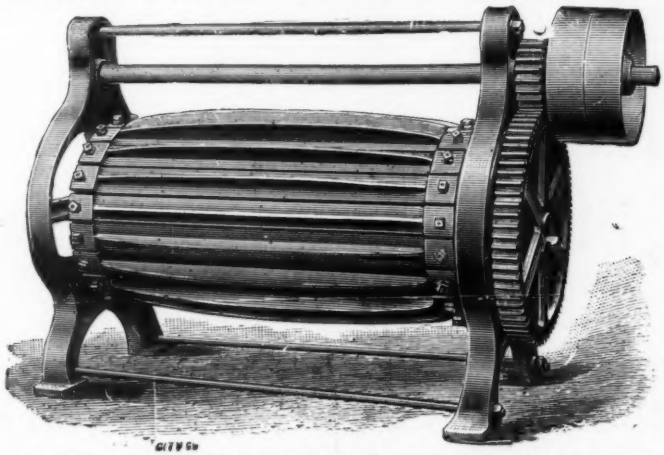
FOUNDRY EQUIPMENTS,

Composition Black Lead,

Plumbago, Core Gum, White Dust, and Coal Dust.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, &c.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

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FOR SALE, "Root's" Patent Foundry Blowers, &c.

No. 2 size by	"Thwaites"	8 in. outlet	£22.
No. 1 ,,	"Allday's"	7 in. ,,	£20.
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No. 3 ,,	"Wilkinson"	6 in. ,,	£17.

Two 7 ft. by 4 ft. Vertical Boilers, as new, each... ... ... £34.
For full details address J. LIGHT, Wolverhampton.

CRUCIBLE STEEL CASTINGS for Collieries, Works, and Engineers, from customers' patterns; machined if desired.—P. T. WOODRUFF AND CO., Machen, Newport, Mon.

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NEW PORTABLE MOULD DRIERS
Moulds dried on the spot in an hour to one hour and a half.
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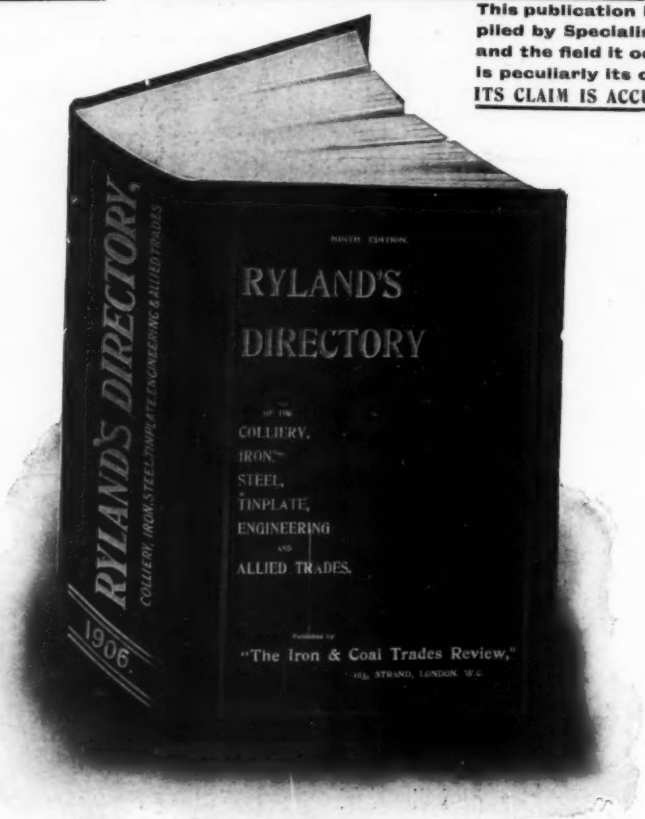

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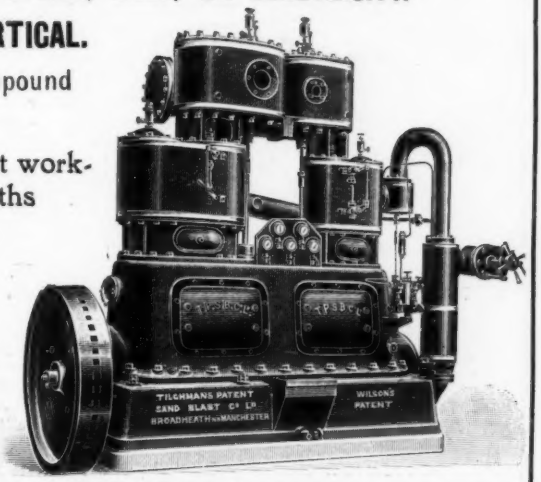

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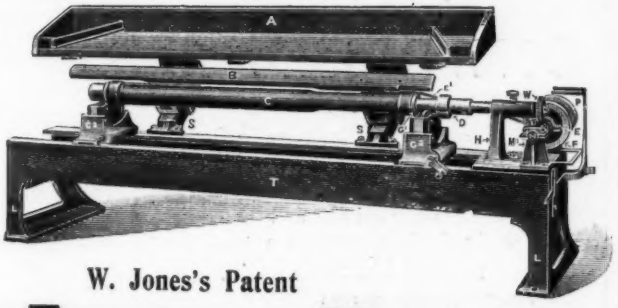

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Will do the work of several men.
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